10 CFR 50.55a(a)(3)(i)

APS

Palo Verde Nuclear Generating Station

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102-05869-DCM/RJR
July 11, 2008

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Sirs:

SUBJECT: Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3 Docket Nos. STN 50-528, 50-529, and 50-530 American Society of Mechanical Engineers (ASME) Code, Section XI, Request for Approval of an Alternative Repair Method – Relief Request No. 39

Pursuant to 10 CFR 50.55a(a)(3)(i), Arizona Public Service Company (APS) requests NRC approval of Relief Request 39, which proposes an alternative repair method to the ASME Code requirements of Section XI. Specifically, APS is proposing the alternatives discussed in the enclosure to this letter to the flaw characterization requirements of IWC-3420 and IWA-3300.

APS requests approval of this relief request within one year from the date of this letter. If you have any questions about this change, please contact Russell A. Stroud, Licensing Section Leader at (623) 393-5111.

Sincerely,

D.C. Mims

DCM/RAS/RJR/gat

Enclosure

cc:	E. E. Collins Jr.	NRC Region IV Regional Administrator
	M. T. Markley	NRC NRR Project Manager
	R. I. Treadway	NRC Senior Resident Inspector

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NRR

Enclosure

Relief Request 39
Proposed Alternative in Accordance with 10 CFR 50.55a(a)(3)(i)

Attachment 1 Structural Integrity Associates, Inc. Calculation 0800802.303, Thermal and Mechanical Stress Analysis of Safety Injection Tank Vent Relief Nozzle Repair

Attachment 2 Structural Integrity Associates, Inc. Calculation 0800802.306, Flaw Tolerance Evaluation of Safety Injection Tank Nozzle Penetration

Relief Request No. 39
Proposed Alternative in Accordance with
10 CFR 50.55a(a)(3)(i)

Background

There are four Safety Injection Tanks (SIT) in each unit which contain borated water and are pressurized with nitrogen. They discharge their contents to the Reactor Coolant System (RCS) following depressurization as a result of a Loss-of-Coolant Accident (LOCA). Each tank is piped into a cold leg of the RCS via a safety injection nozzle located on the RCS piping near the reactor vessel inlet. The tank vent nozzle is on the upper head of the tank in the nitrogen blanket. Each tank is approximately 41 ft. high and 9 ft. in diameter. The operating level is maintained at approximately 32 ft. to 34 ft. The upper alarm limit is set at approximately 35 ft. Technical Specifications require the boron concentration be in the range of 2300 ppm to 4400 ppm; and that the nitrogen cover pressure be maintained from 600 pounds per square inch, gauge (psig) to 625 psig. The SIT operates at a temperature range of 60° Fahrenheit (F) to 140° F.

On Thursday June 5, 2008, Palo Verde Nuclear Generating Station (PVNGS) declared the Unit 1 SIT 1A inoperable when a small leak was identified at the annulus between the tank and the vent line during the performance of a leak test.

Ultrasonic (UT) examination of the carbon steel material of the vessel around the nozzle attachment weld (Alloy 82/182) showed no flaws. It appeared that the leak was due to flaw(s) in the 82/182 weld material. The nozzle repair consisted of making a new J-weld to attach the nozzle at the outer surface of the vessel. The original J-weld on the inner surface was left in place. The design of the new configuration complies with the construction Code. The weld was completed and examined visually and nondestructively in full compliance with the requirements of ASME Sections III and XI.

After the repair was completed, an Operability Determination (OD) of SIT 1A was completed and the SIT was determined to be operable with an action to submit a relief request in a timely manner after completion of the OD.

ASME Code Components Affected

ASME Item number: C2.20
Description: Safety Injection Tank (SIT) Nozzles
Code Class: 2

Applicable Code Editions and Addenda

Third 10-year Inservice Inspection Interval Code for PVNGS for Units 1, 2, and 3: American Society of Mechanical Engineers (ASME) Code, Section XI, 2001 Edition, 2003 Addenda

Applicable Code Requirement

IWC-3420, Characterization, states that each detected flaw or group of flaws shall be characterized by the rules of IWA-3300 to establish the dimensions of the flaw(s). These dimensions shall be used in conjunction with the acceptance standards of IWC-3500.

IWA-3300, Flaw Characterization, states that flaws detected by inservice examinations shall be sized by the bounding rectangle or square for the purpose of description and dimensioning.

Reason for Request

Unit 1 SIT 1A was indicating a gradual lowering trend in nitrogen pressure. During the investigation of potential leak paths, a leakage source was identified at the 2 inch vent line nozzle annulus (see Figure 1) where leak testing (snoop method) indicated a two bubble per second leak.

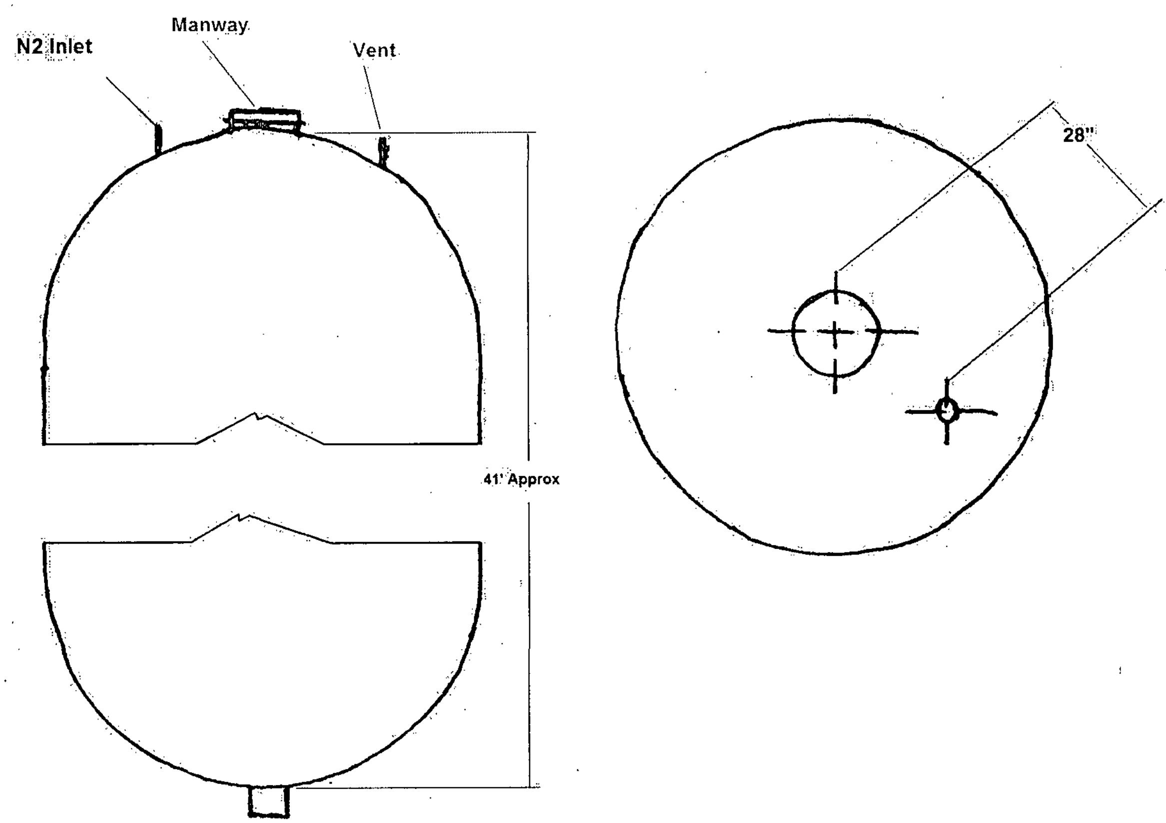

Figure 1

APS repaired the leak by moving the pressure boundary from the inside of the SIT to the outside by making a partial penetration nozzle attachment weld as shown in Figure 2. This resulted in leaving the flaw in the original weld in place.

Removal of the flaw would require access to the nozzle weld on the interior of the SIT. This would require scaffolding both outside and inside the SIT. The limited size of the manway and the distance from the manway to the repaired nozzle presented significant personnel safety concerns such as, confined space entry due to the small size of the manway and personnel fall protection due to the 40 foot distance from the weld to the tank bottom (see Figure 1). Additionally, the difficulty in controlling entry of foreign material from grinding and welding into the SIT was considered. The requirements of ASME Section IWC-3420 and IWA-3300 require that a flaw or group of flaws be characterized to establish the dimensions of the flaw(s) and that these dimensions be used in conjunction with the acceptance standards of IWC-3500, Acceptance Standards. Characterization by UT is not possible due to the geometry of the partial penetration weld.

Due to the personnel safety concerns and the inability to characterize the flaw, APS developed an alternative that postulated a worst-case flaw in the original weld, evaluated its acceptance using IWB-3600, Analytical Evaluation of Flaws, and determined that the defective J-weld could be left in place. The postulated flaw is an axial crack in the Alloy 82/182 weld metal. This postulated crack represents the worst-case for the most-likely weld discontinuities such as porosity and slag inclusions that caused the leak. This material, as well as the base material, are not susceptible to stress corrosion cracking at 140° F in a nitrogen environment. In addition, no operating experience concerning incidents of stress corrosion cracking of Alloy 600/182/82 in an air or nitrogen environment at ambient temperature was found.

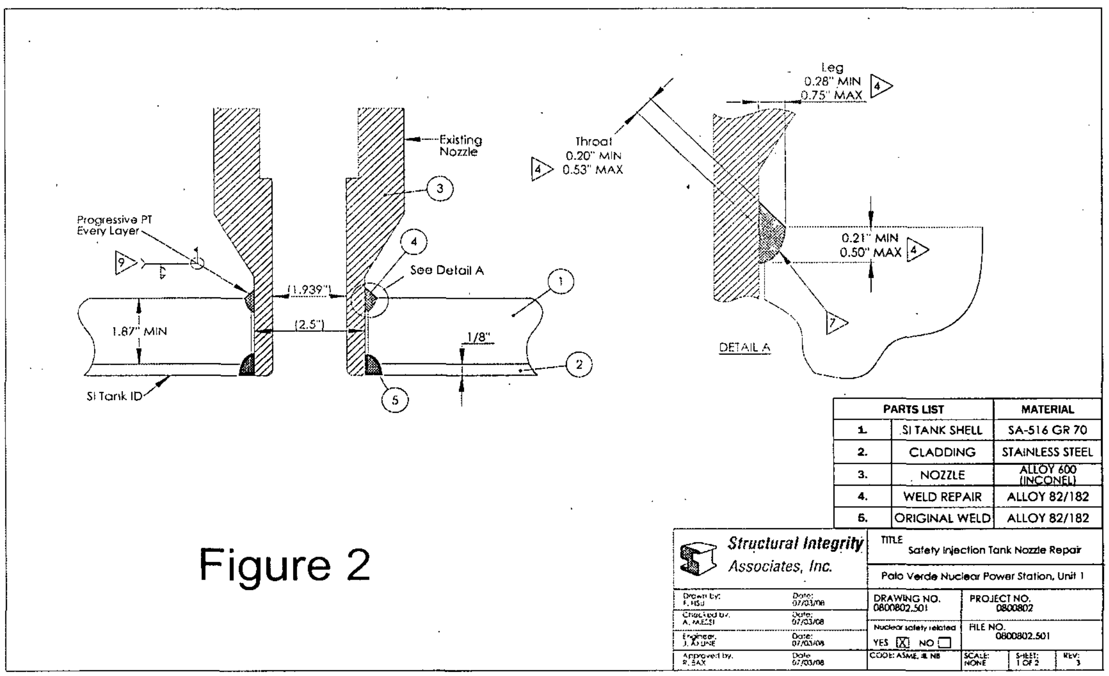

Figure 2

Proposed Alternative and Basis For Relief

Pursuant to 10 CFR 50.55a(a)(3)(i), APS is proposing an alternative to the required flaw characterization of IWC-3420 and IWA-3300. APS is not proposing any alternative to the required successive examinations (IWB/IWC-2420, Successive Inspections).

This Relief Request seeks approval to allow the analyzed flaw to remain in-place for the remainder of the expected plant life for Unit 1 and to allow the application of this alternative to any similar repairs on the remaining safety injection tanks in Unit 1 as well as Units 2 and 3.

Proposed Alternative

In lieu of fully characterizing/sizing the existing flaw, APS has assumed a worst-case flaw and performed the following:

- a Thermal and Mechanical Stress Analysis of the repair (Attachment 1), and
- a Flaw Tolerance Evaluation (Attachment 2) to ensure that the postulated, worst-case flaw, meets the acceptance criteria of the ASME Code.

The Flaw Tolerance evaluation resulted in a postulated final flaw of 0.352 inch (original depth of the partial penetration weld plus projected growth due to fatigue) in the carbon steel material of the vessel. This postulated flaw was analyzed in accordance with IWB-3600 and shown to be acceptable to the IWB-3612, Acceptance Criteria Based on Applied Stress Intensity Factor. The flaw evaluation demonstrates that the flaw will remain within acceptable Section XI limits for the expected 40-year plant life (remaining plant operating license plus 20-year life extension).

Basis for Relief

When moving the pressure boundary of a tank attached nozzle from the inside to the outside of the tank, the flaw must be characterized and shown not to impact the integrity of the tank or new weld. In lieu of fully characterizing/sizing the existing flaw, APS postulated a worst-case flaw and performed the analysis delineated above.

The analysis demonstrates that any flaw in the nozzle or attachment weld will not propagate such that the structural integrity of the new weld or the tank boundary is affected. Therefore, the proposed alternative provides an acceptable level of quality and safety as required by 10 CFR 50.55a(a)(3)(i).

Duration of Proposed Alternative

APS requests that this relief be granted for this repair to PVNGS Unit 1 and be applicable to any subsequent similar repairs to Units 1, 2, or 3 SITs and that the relief remain in effect for the remainder of the expected plant life. The current operating licenses are scheduled to expire on June 1, 2025, April 24, 2026 and November 25, 2027, for Units 1, 2, and 3 respectively. On May 15, 2008, APS filed its advance notice of intent to pursue operating license renewal, Agency Document Access and Management System (ADAMS) ML081420365.

Commitments

There are no commitments made in this request.

Conclusion

10 CFR 50.55a(a)(3) states:

> "Proposed alternatives to the requirements of paragraphs (c), (d), (e), (f), (g), and (h) of this section or portions thereof may be used when authorized by the Director of the Office of Nuclear Reactor Regulation. The applicant shall demonstrate that:
>
> (i) The proposed alternatives would provide an acceptable level of quality and safety, or
>
> (ii) Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety."

The proposed alternative discussed in this relief request provides an acceptable level of quality and safety. Therefore, APS requests that the proposed alternative be authorized pursuant to 10 CFR 50.55a(a)(3)(i).

Precedents

1. Palo Verde Relief Request 31 Revision 1, Safety Evaluation dated September 12, 2006, (TAC NOS. MC9159, MC9160, AND MC9161) Agencywide Documents Access and Management System (ADAMS) Accession Number: ML062300333.

   In lieu of fully characterizing/sizing the potentially existing flaws, APS assumed worst-case flaws in the Alloy 600 base and weld material and used the methodology presented in NRC-approved Westinghouse Topical Report (TR) WCAP-15973-P, Revision 01, "Low-Alloy Steel Component Corrosion Analysis Supporting Alloy 600/690 Nozzle Repair Program," to support the request. APS reviewed the bases and arguments presented in the TR and determined that the TR bases and arguments can be applied to the previously repaired Unit 1, 2, and 3 hot-leg small-bore nozzles and demonstrated compliance with ASME Section XI criteria for the remaining plant operating license plus 20-year life extension.

   The difference between Relief Request 31, Revision 1 and Relief Request 39 is the environment. Relief Request 31, Revision 1 had to account for a higher operating temperature and exposure to borated water.

2. Palo Verde Relief Request 29 Safety Evaluation dated November 11, 2004, (TAC NOS. MC3606, MC3607, AND MC3608) ADAMS Accession Number: ML043130170.

   Relief Request 29 provided relief from certain flaw evaluation requirements and from the successive examination of the remnant pressurizer heater sleeves left in-place after performing a half-sleeve mid-wall weld repair in Units 1 and 3. The flaw evaluation supporting this request utilized both Linear Elastic Fracture Mechanics (LEFM) and Elastic Plastic Fracture Mechanics (EPFM), and demonstrated compliance with ASME Section XI criteria for the remaining plant operating license plus 20-year life extension.

   The difference between Relief Request 29 and Relief Request 39 is the environment of the analysis. Relief Request 29 had to account for a higher operating temperature and exposure to borated water.

Attachment 1

Structural Integrity Associates, Inc. Calculation 0800802.303, Thermal and Mechanical Stress Analysis of Safety Injection Tank Vent Relief Nozzle Repair

Structural Integrity Associates, Inc.

CALCULATION PACKAGE

File No.: 0800802.303

Project No.: 0800802 ☒ Q ☐ Non-Q

PROJECT NAME: ASME Code Evaluation of Safety Injection Tank Nozzle Repair

CONTRACT NO.: Master Agreement No. 500299013

CLIENT: Arizona Public Service Co.

PLANT: Palo Verde Nuclear Generating Station, Unit 1

CALCULATION TITLE: Thermal and Mechanical Stress Analyses of Safety Injection Tank Nozzle Repair

Document Revision	Affected Pages	Revision Description	Project Manager Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
0	1 – 16 A1-A2 Computer Files	Original Issue	G.A. Miessi GAM 07/03/08	P. Jing PJ 07/03/08 F. H. Ku FHK 07/03/08 A. Chintapalli AC 07/03/08

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1.0 INTRODUCTION

The purpose of this calculation is to perform stress analyses on the vent relief nozzle of the Safety Injection Tank (SIT) 1A at Palo Verde Nuclear Generating Station, Unit 1, due to thermal and unit mechanical loads.

Stress paths are extracted throughout the finite element model the location of the original weld and the stress results are stored in computer files for subsequent ASME Code evaluations.

2.0 DESIGN INPUTS

2.1 Finite Element Model

The finite element model is developed in a previous calculation package [1] using the ANSYS finite element software package [2]. The finite element model is constructed using 3-D structural solid (SOLID45) elements and includes a portion of the SI Tank shell, the vent relief nozzle, the original J-groove weld, and the weld repair, as shown in Figure 1.

2.2 Material Properties

The material properties are included in the finite element model developed in Reference 1.

3.0 METHODOLOGY

The unit mechanical loading includes unit internal pressure (P = 1,000 psi), unit nozzle force loading (Fx = Fy = Fz = 1,000 lbs) in X, Y, and Z directions, and unit nozzle moment loading (Mx = My = Mz =1,000 in-lbs) about X, Y, and Z axes.

In support of future ASME Code evaluations, eight (Paths 1-8) linearized through-wall stress paths are defined for the stress and fatigue evaluations, and one through-wall hoop stress path is defined for the crack growth evaluation (Path 9). The path definitions are shown in Figure 2.

Note that for Paths 1 through 7, four sub-paths are defined (downhill, +90 deg., uphill, -90 deg. azimuths); for Paths 8 and 9, only two sub-paths are defined (downhill and uphill azimuths).

4.0 ANALYSIS

Seven separate mechanical loading analyses and one thermal loading analysis are performed as described in the following sections. Symmetric boundary conditions are applied on the symmetry planes of the SI Tank, as shown in Figure 3.

4.1 Mechanical Loading Analyses

Unit internal pressure, unit force loadings, and unit moment loadings are performed. The mechanical loads are analyzed at a uniform body temperature of 70° and reference temperature of 70°F.

4.1.1 Unit Internal Pressure

A unit internal pressure of 1,000 psi is applied on the interior surfaces of the model, as well as on the annulus region of the nozzle penetration, assuming the original J-groove weld is flawed and hence causing leakage. An induced end-cap load is applied to the top free end of the nozzle in the form of a tensile axial pressure, and the value is calculated below. The applied pressure load is shown in Figure 4.

$$P_{end\text{-}cap} = \frac{P \cdot r_{inside}^2}{\left(r_{outside}^2 - r_{inside}^2\right)} = \frac{1000 \cdot (1.203)^2}{\left(1.5^2 - 1.203^2\right)} = 1803 \text{ psi}$$

where,

$P_{end\text{-}cap}$	= End cap pressure on nozzle end (psi)
P	= Applied internal pressure (psi)
r_{inside}	= Inside radius of nozzle top end (in)
$r_{outside}$	= Outside radius of nozzle top end (in)

4.1.2 Unit Forces in X, Y, and Z Directions

A unit force of 1,000 lbs in each of the three directions is applied on the top free end of the nozzle to simulate mechanical force loads acting on the nozzle. The force load is applied at the center location of the nozzle top end via the rigid Pilot Node feature in ANSYS [2] through CONTA174 and TARGE170 elements. Sample illustration for the FX application is shown in Figure 5.

4.1.3 Unit Moment about X, Y, and Z Axes

A unit moment of 1,000 in-lbs in each of the three orthogonal axes is applied on the free end of the nozzle to simulate mechanical piping moment loads acting on the nozzle. The force load is applied at the center location of the nozzle top end via the rigid Pilot Node feature in ANSYS [2] through CONTA174 and TARGE170 elements. Sample illustration for the MX application is shown in Figure 6.

4.2 Thermal Analysis

A steady state body temperature of 200°F design temperature [3] is applied on the entire model, with a reference temperature of 70°F.

5.0 RESULTS

Representative total stress intensity contour plots are shown in Figures 7 through 9 for the mechanical loading analyses, and Figure 10 for thermal loading analysis. Note that since the analyses are linear elastic, localized stress concentration can occur at the crevice of the welds as observed in Figure 7.

6.0 CONCLUSION

Unit mechanical load and thermal stress analyses are performed on the Safety Injection Tank Vent Relief Nozzle. Linearized and mapped stress results are extracted from the analyses for Paths 1 through 9 in support of the subsequent ASME Code evaluations.

The associated computer files for the analyses and stress results are listed in Appendix A.

7.0 REFERENCES

1. SI Calculation 0800802.302, Rev. 0, "Finite Element Model Development of Safety Injection Tank Vent Relief Nozzle Repair."
2. ANSYS/Mechanical, Release 8.1 (w/Service Pack 1), ANSYS Inc., June 2004.
3. APS Supplier Number Sdoc N001-11.02-41-1, Bechtel Power Corp. File No. 8836.10-01, Rev. 8, "Analysis of a System 80 Safety Injection Tank," SI File No. 0800802.201.

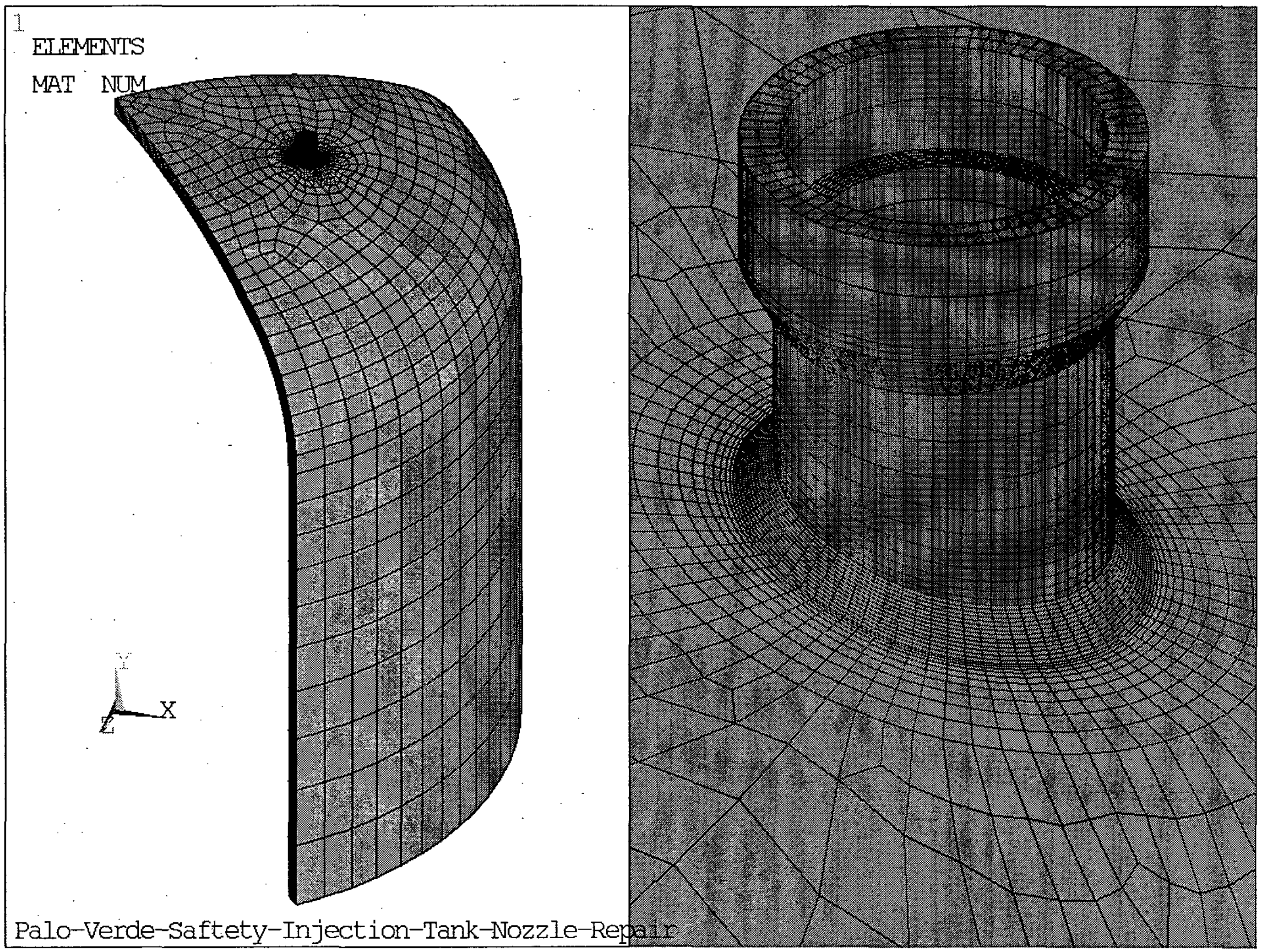

Figure 1: Finite Element Model of the Safety Injection Tank Vent Relief Nozzle

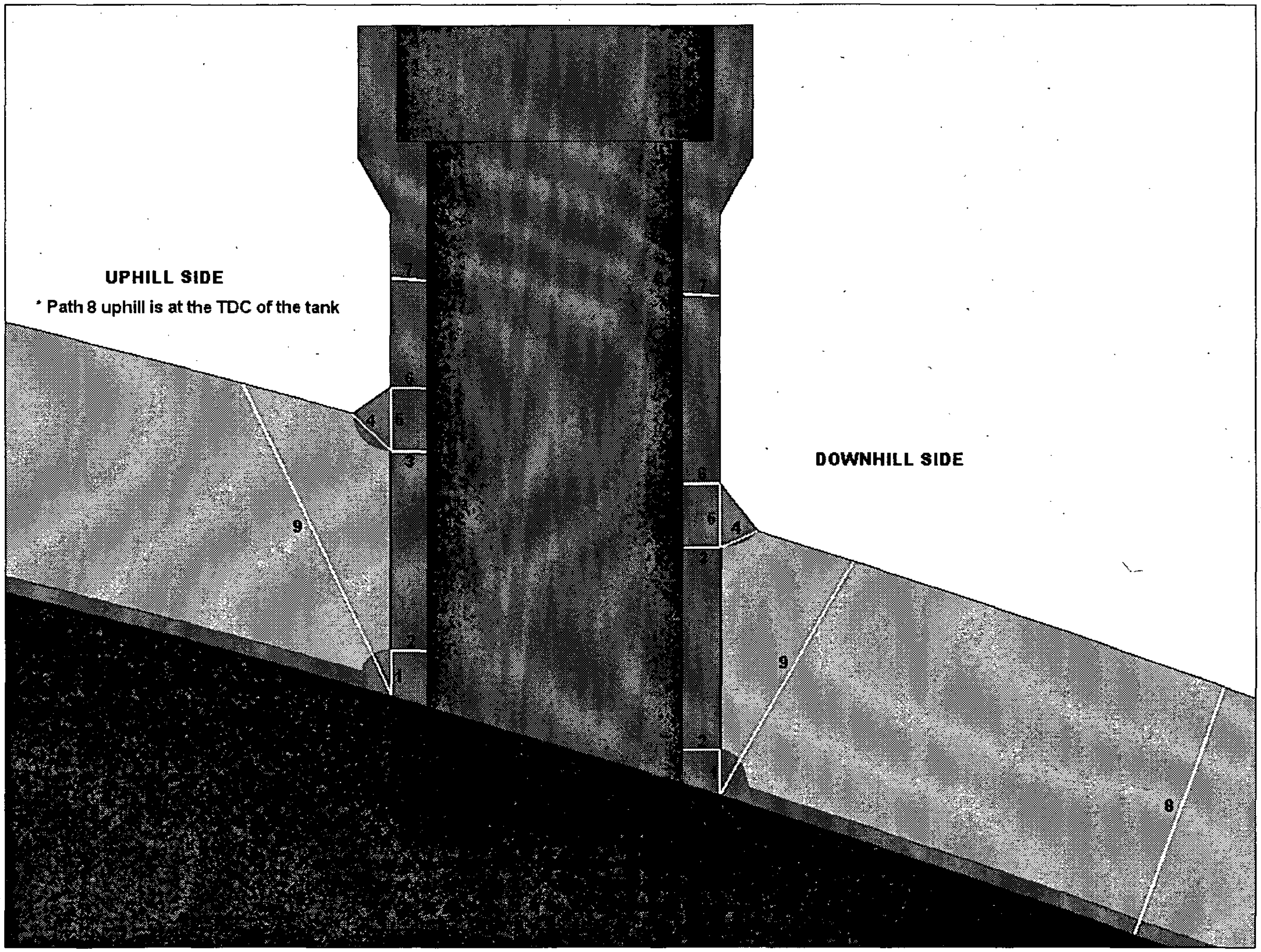

Figure 2: Path Definitions for Stress Results Extraction

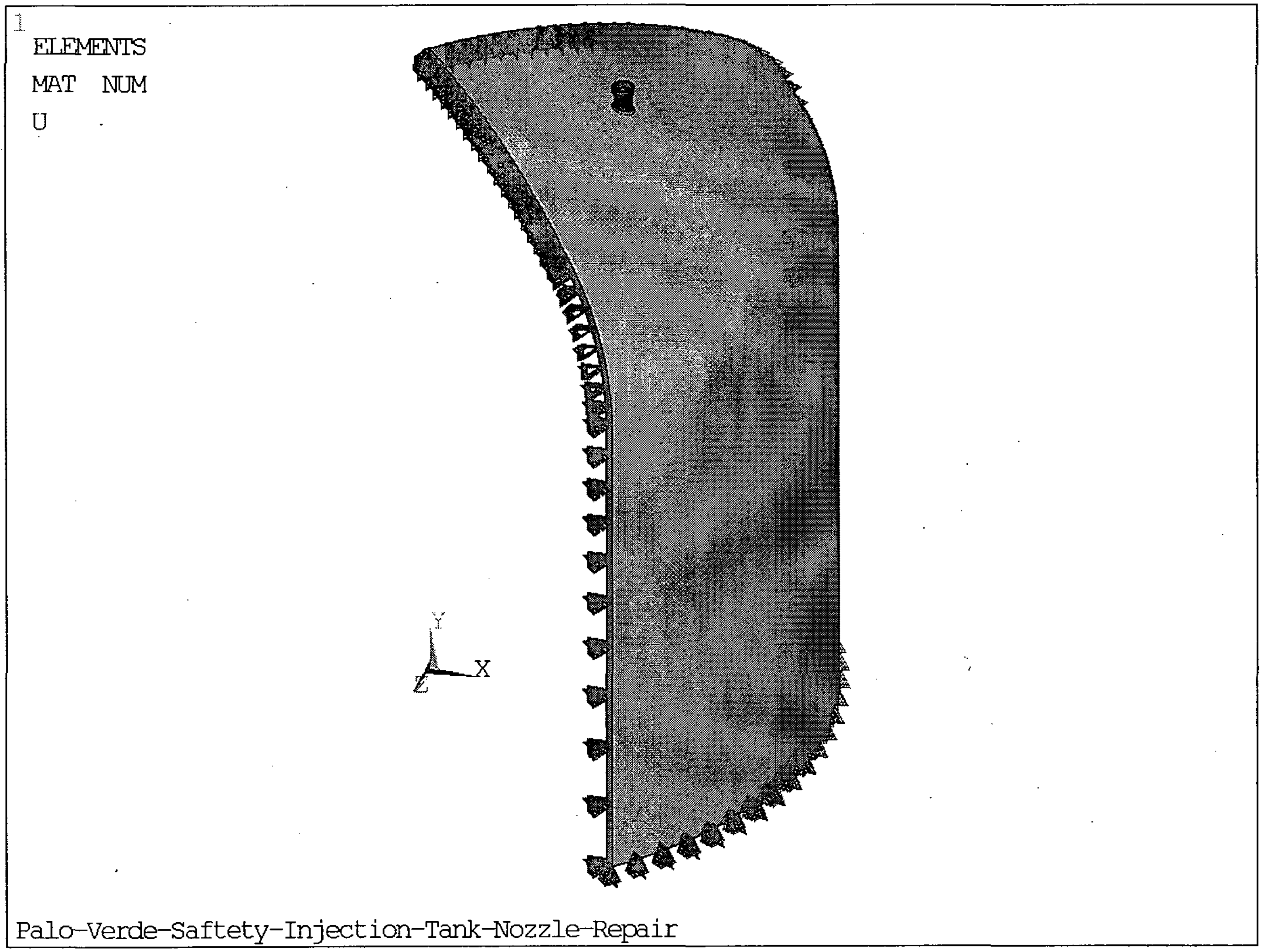

Figure 3: Applied Boundary Conditions

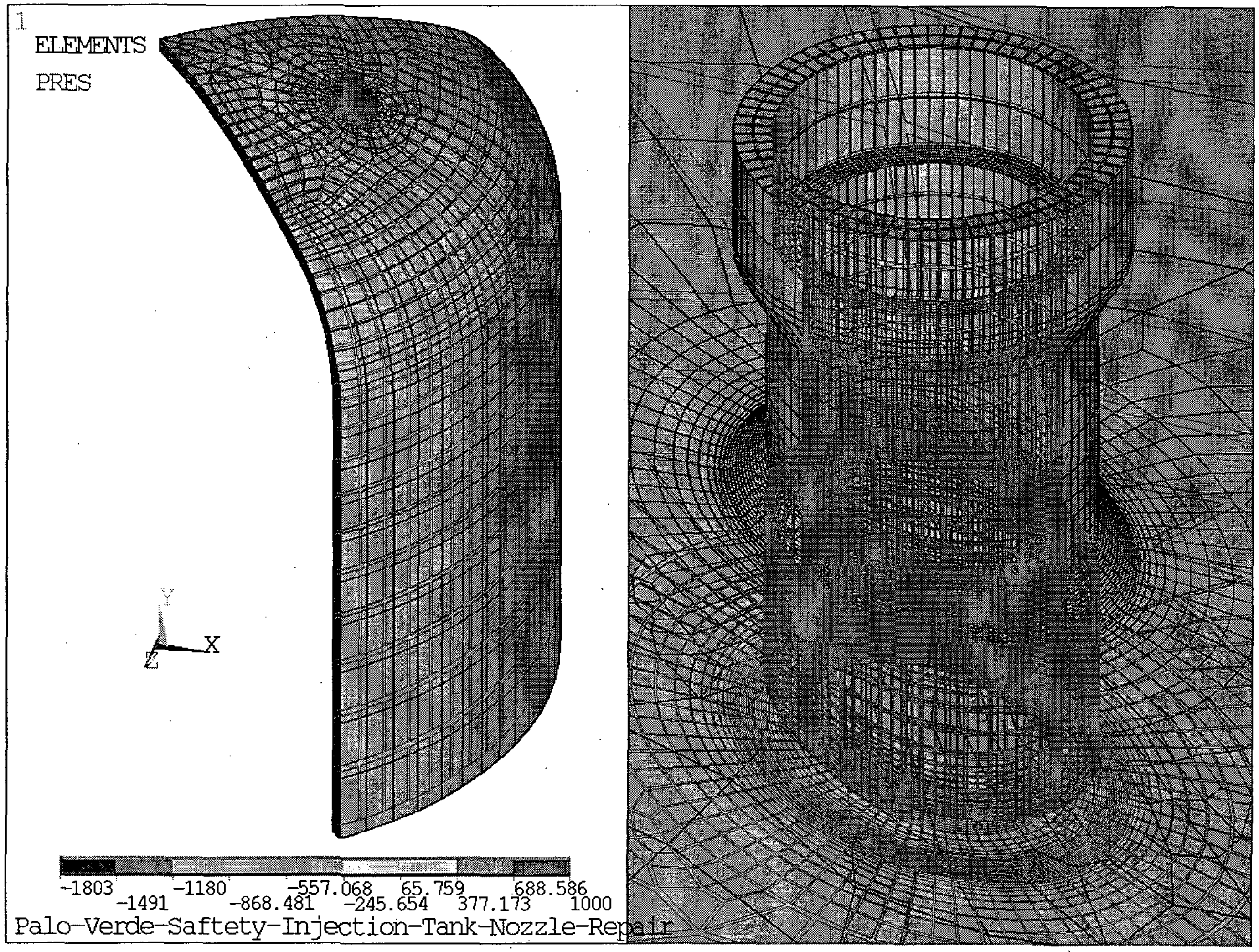

Figure 4: Applied Internal and End Cap Pressure

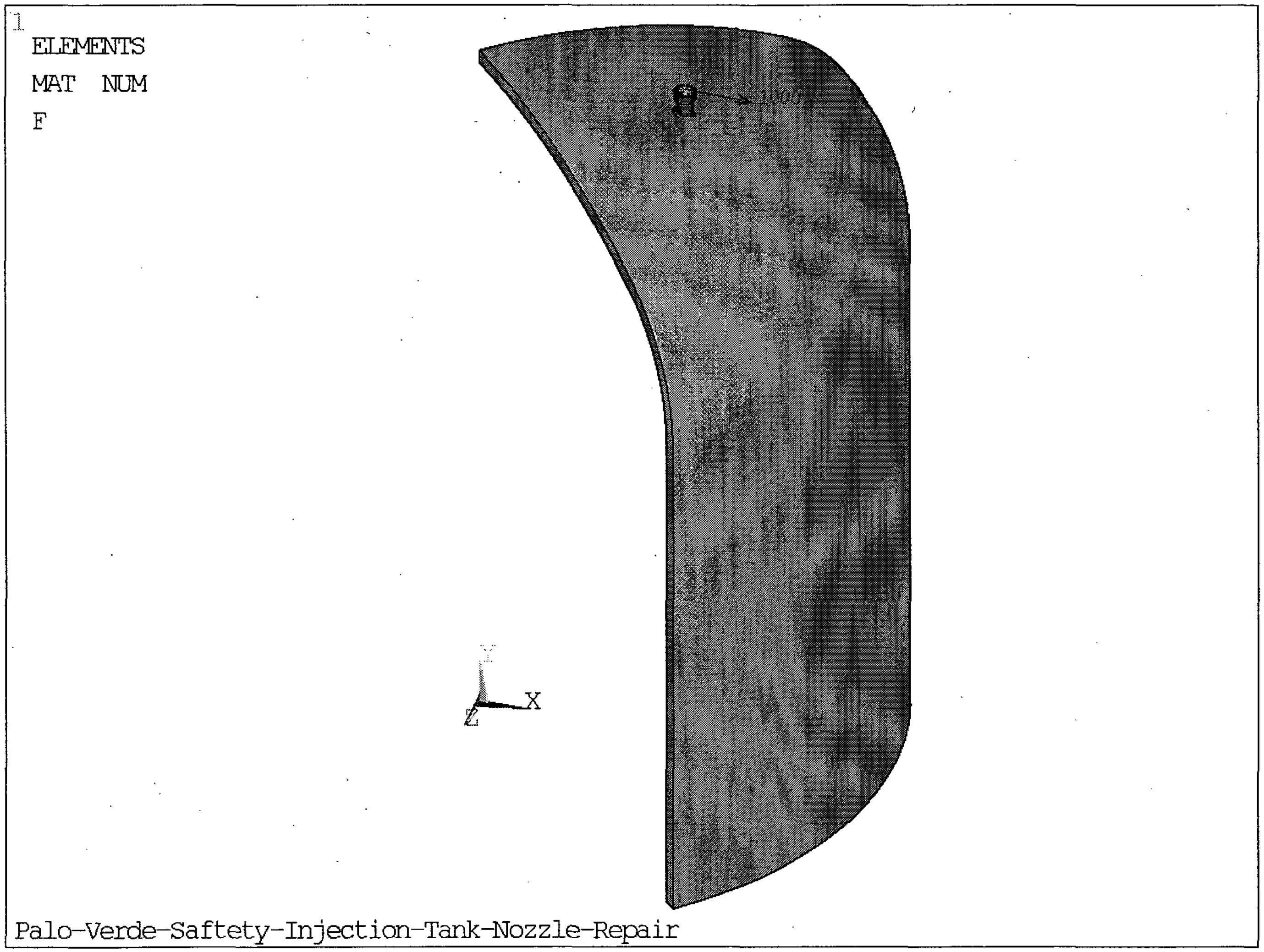

Figure 5: Applied Force Load in the X-Direction

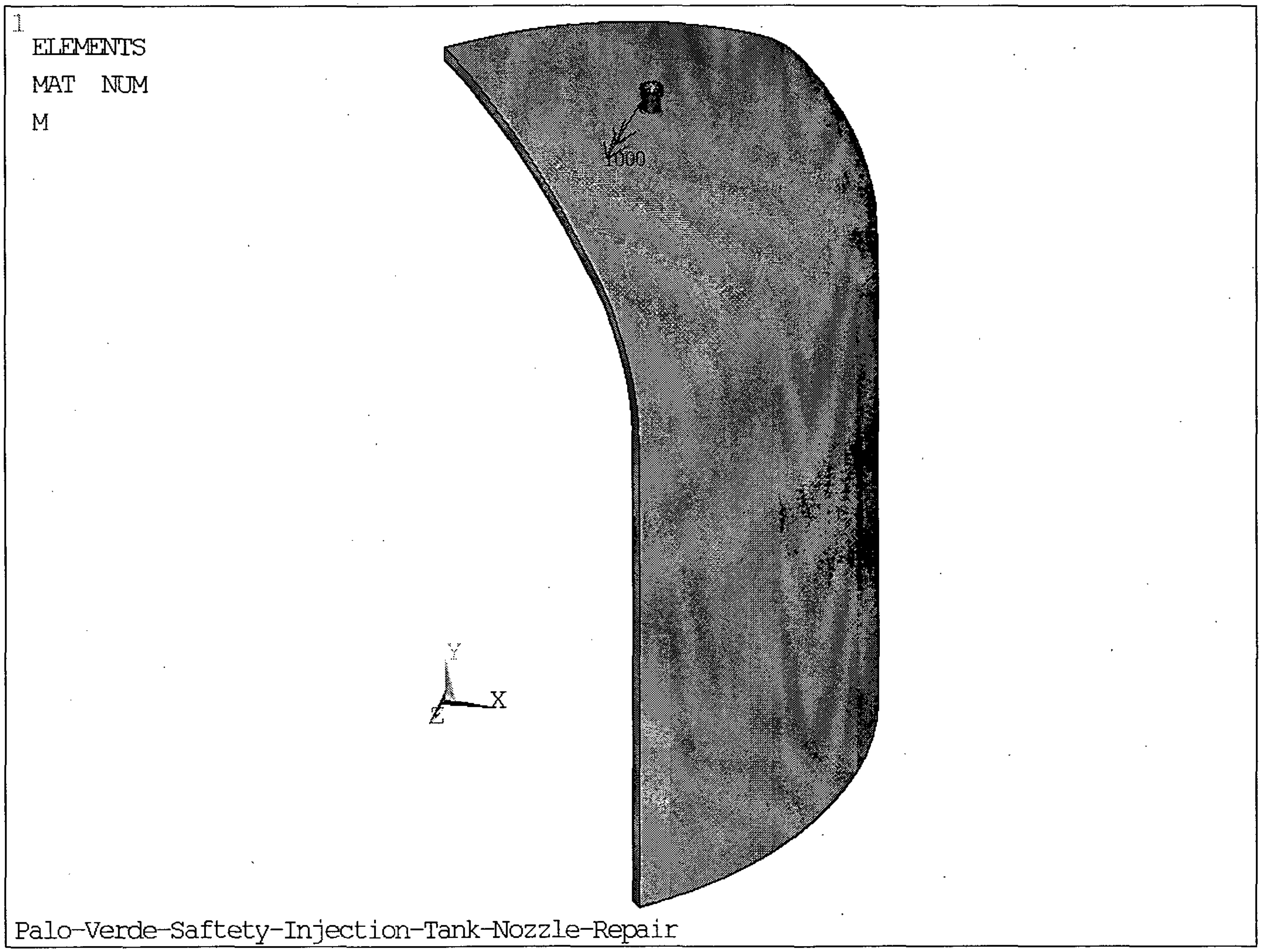

Figure 6: Applied Moment Load About Z-Axis

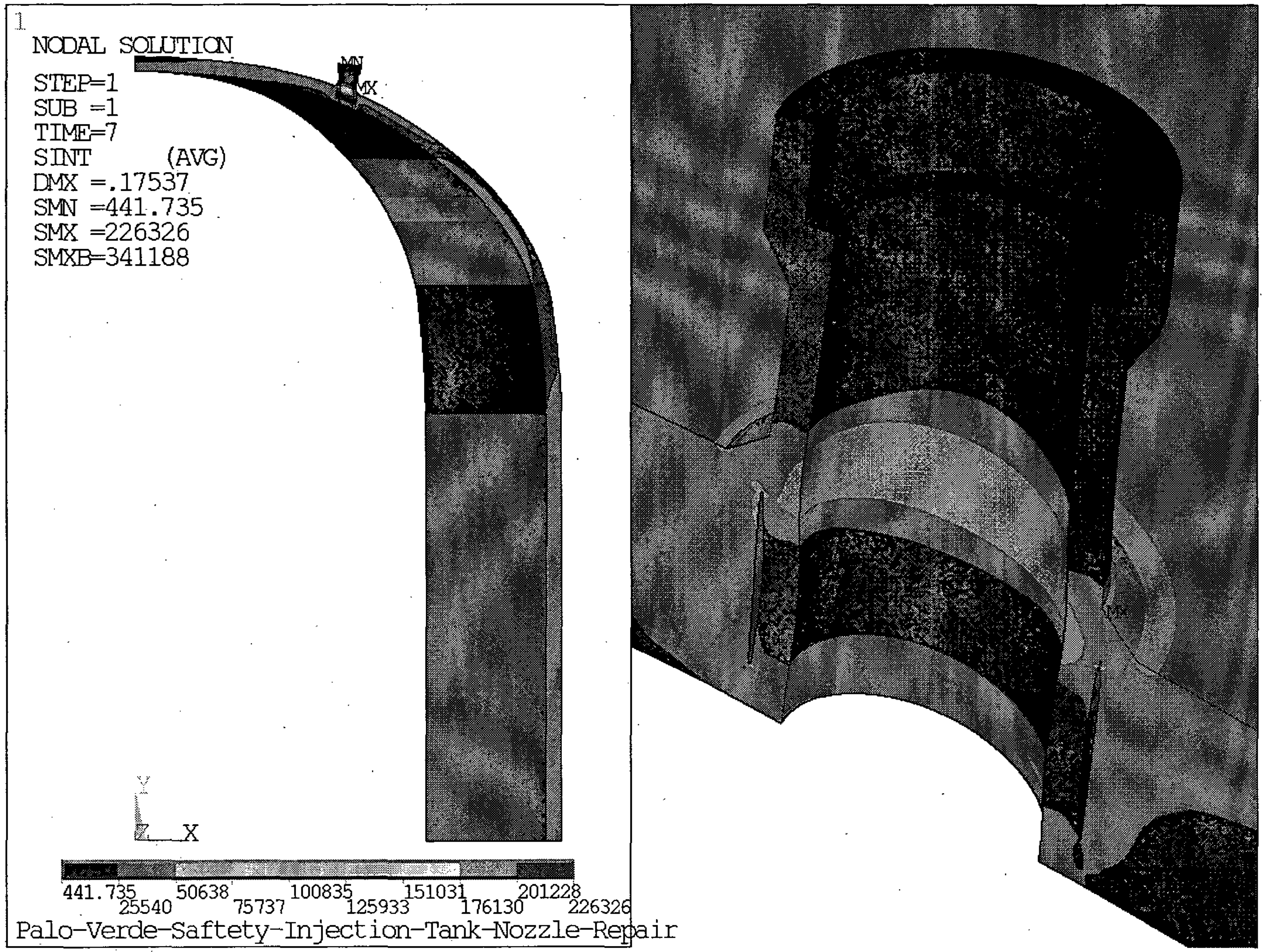

Figure 7: Total Stress Intensity Results for Internal Pressure Load, Half-Sectional View

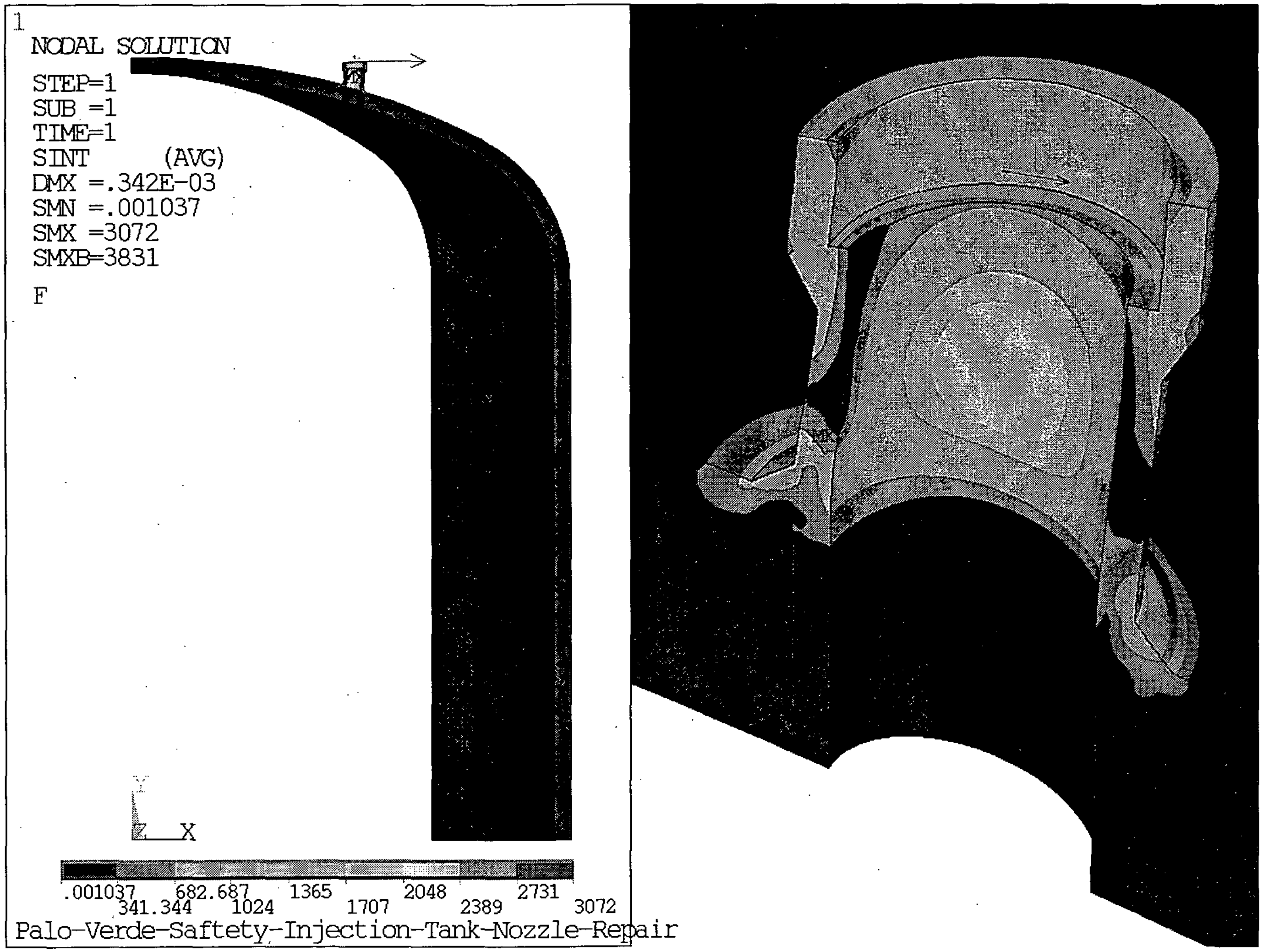

Figure 8: Total Stress Intensity Results for FX Load, Half-Sectional View

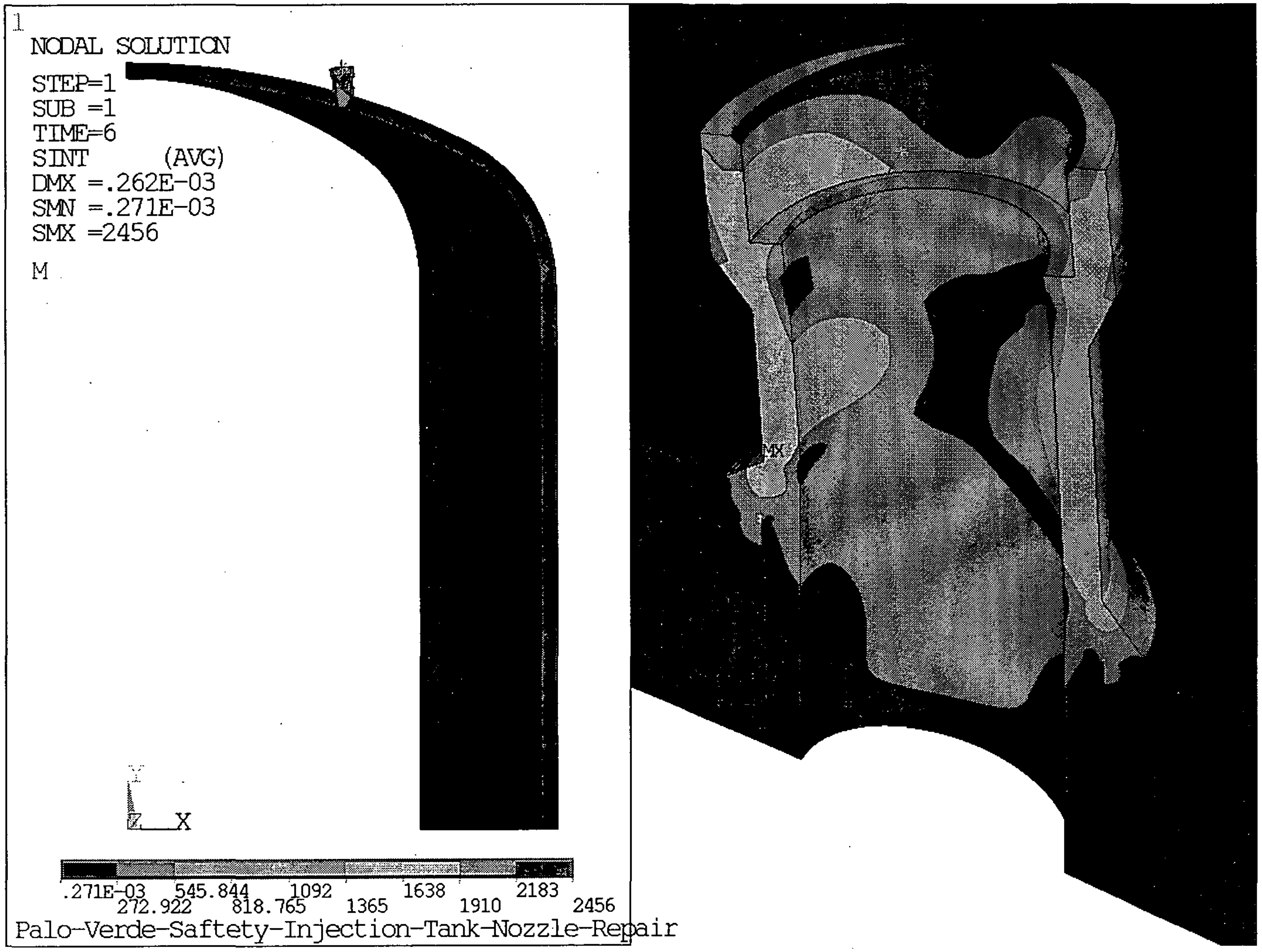

Figure 9: Total Stress Intensity Results for MZ Load, Half-Sectional View

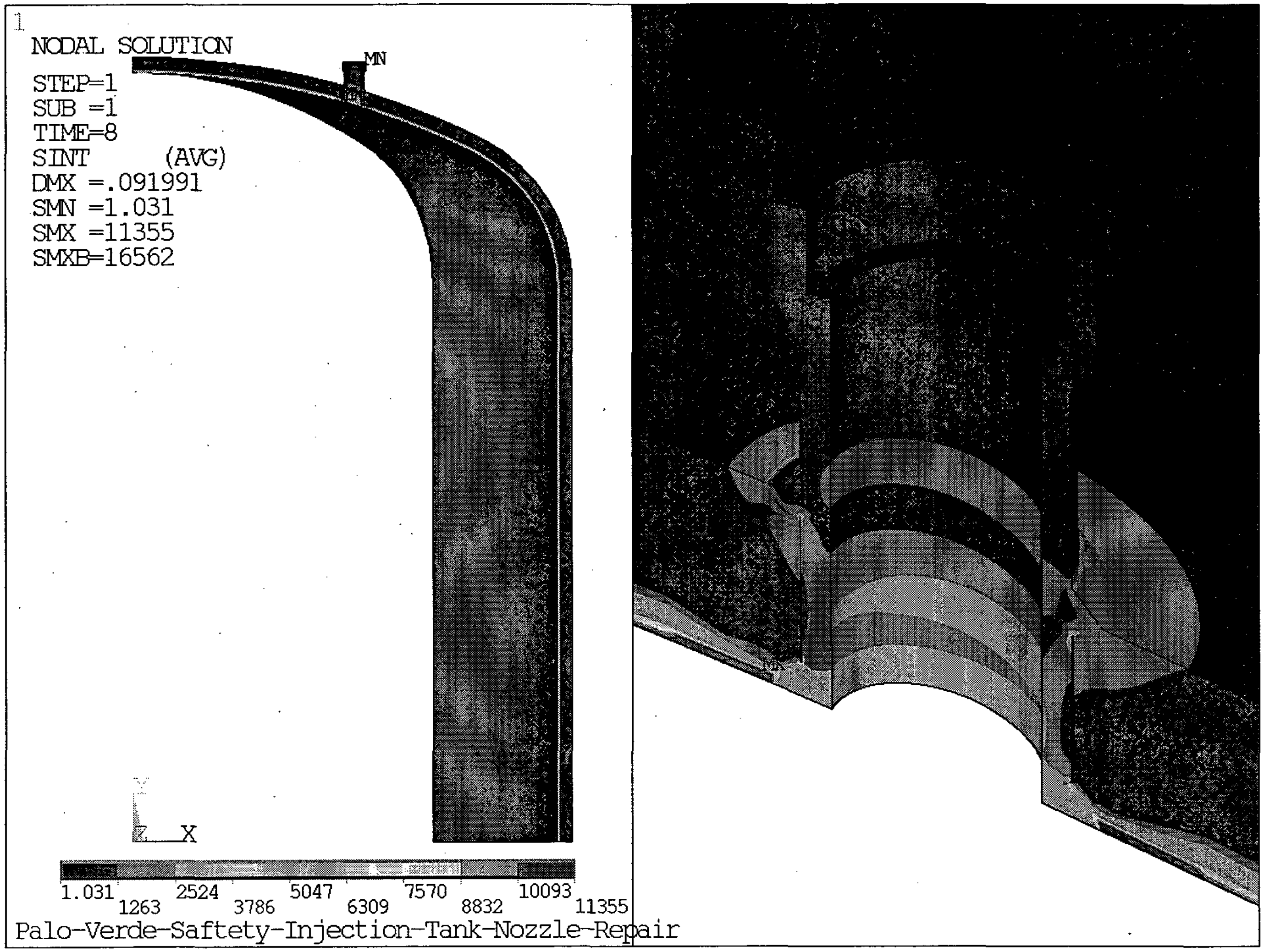

Figure 10: Total Stress Intensity Results for Thermal Load, Half-Sectional View

APPENDIX A

ANSYS INPUT AND OUTPUT FILES

Filename	Description
STACK.INP	Controller input file to submit the following files
GEOM3D.INP	Finite element model input file (from [2])
Pressure.INP	Unit internal pressure input file
FX.INP	Force in X direction
FY.INP	Force in Y direction
FZ.INP	Force in Z direction
MX.INP	Moment about X-axis
MY.INP	Moment about Y-axis
MZ.INP	Moment about Z-axis
THERMAL.INP	Thermal load
POST_PATH.INP	Post-processing input file to extract path stresses
*_LIN.OUT	Linearized stress output files for paths 1 through 8 (* = load case name)
*_MAP.OUT	Mapped hoop stress output files path 9 (* = load case name)

Attachment 2

Structural Integrity Associates, Inc. Calculation 0800802.306
Flaw Tolerance Evaluation of Safety Injection Tank Nozzle Penetration

Structural Integrity Associates, Inc.	File No.: 0800802.306
CALCULATION PACKAGE	**Project No.:** 0800802 ☒ Q ☐ Non-Q

PROJECT NAME: ASME Code Evaluation of Safety Injection Tank Nozzle Repair

CONTRACT NO.: Master Agreement No. 500299013

CLIENT: Arizona Public Service Co.	**PLANT:** Palo Verde Nuclear Generating Station, Unit 1

CALCULATION TITLE: Flaw Tolerance Evaluation of Safety Injection Tank Nozzle Penetration

Document Revision	Affected Pages	Revision Description	Project Manager Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
0	1 – 20 A1 B1 – B10 Computer Files	Original Issue	G. A. Miessi GAM 07/10/08	G. A. Miessi GAM 07/10/08 S. S. Tang SST 07/10/08

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1.0 INTRODUCTION

A leak was discovered at a vent relief nozzle of the safety injection tank (SIT) 1A at Palo Verde Unit 1. The vent relief nozzle is attached to the SIT shell by a partial penetration J-Groove weld at its inside surface. A repair which consists of a J-Groove weld and a cover fillet weld at the outside surface of the SIT shell is designed to address the leakage. The repair design effectively moves the pressure boundary of the safety injection vessel from its ID surface to its OD surface.

The objective of this calculation is to perform a fracture mechanics analyses to ensure that a postulated nozzle corner crack in the SIT vessel shell meet the acceptance criteria of ASME Code, Section XI [1].

2.0 TECHNICAL APPROACH

The fracture mechanics evaluation consists of the following tasks:

- Determine the bounding through-wall stress distributions based on the finite element stress analysis results documented in Reference 2.
- Determine the stress intensity factors for a postulated flaw in the existing partial penetration weld at the SIT inside surface.
- Perform a flaw evaluation based on the guidelines of ASME B&PV Code, Section XI [1] to calculate the allowable flaw size for the vent relief nozzle.
- Perform a fatigue crack growth analysis to compute end-of-evaluation period flaw sizes to compare to the allowable flaw sizes computed above.

3.0 DESIGN INPUT

3.1 Design and Operating Conditions

The design and operating conditions obtained from Reference 3 are as follows:

Design Conditions:

- Design pressure, internal = 700 psi
- Design pressure, external = 100 psi
- Design temperature = 200°F

Operating Conditions:

- Operating pressure, internal = 610 psi
- Operating pressure, external = 5 psi
- Operating temperature = 140°F

3.2 Pipe Dimensions

The SIT vent relief nozzle penetration dimensions are obtained from Reference 3. The principal dimensions are:

- SIT Vessel Shell Minimum Thickness: 1.87"
- SIT Vessel Cladding Thickness: 1/8"
- Nozzle Outside Diameter: 2.5"
- Nozzle Inside Diameter: 1.939"

3.3 Material Properties

The material of the different components of nozzle penetration is specified in Reference 3 as follows:

- SIT Vessel Shell: SA-516 Grade 70
- Vent Relief Nozzle: Alloy 600
- SIT Vessel Shell Cladding: Stainless Steel

3.4 Applied Stresses

The applied stresses are obtained from Reference 2 which contains stress results from detailed three-dimensional finite element analyses of the SIT vent relief nozzle repair design. The stress analyses performed with the ANSYS finite element analysis program [4] included internal pressure, attached piping loads and the steady-state thermal condition.

Since the postulated flaw is the entire cross-section of the existing J-Groove weld which is oriented axially with respect to the nozzle axis, the results of the Reference 2 stress analyses are post-processed to obtain the bounding through-wall hoop stress distribution at the nozzle penetration for each of the applied mechanical and thermal loads. The through-wall normal stress distributions at Path 9 at the uphill and downhill locations, as shown in Figure 1, are extracted from the finite element analysis of Reference 2. Then, the through-wall normal stress distributions are obtained by applying the appropriate scale factors presented in Reference 12 for the normal operating internal pressure, mechanical and thermal loads to the results from the unit load analyses of Reference 2. The resulting maximum through-wall hoop stress distributions at Path 9 are listed in Table 1 and presented in Figure 2.

The ANSYS post-processing files containing the hoop stress distributions are listed in Appendix A.

Table 1: Maximum Hoop Stresses (psi)

Distance from Nozzle Corner (in)	PRESSURE	THERMAL	FX	FY	FZ	MX	MY	MZ
0	23238.2	-2673.2	-184.8	279.9	0.0	0.0	0.0	63.7
0.12801	21670.4	-2448.8	-148.3	226.9	0.0	0.0	0.0	47.9
0.25601	22855.3	-1904.4	-117.1	186.6	0.0	0.0	0.0	38.2
0.38402	22437.4	67.9	-85.6	145.5	0.0	0.0	0.0	28.5
0.51203	21146.5	216.1	-65.2	109.3	0.0	0.0	0.0	20.6
0.64003	20625.2	329.0	-48.3	78.5	0.0	0.0	0.0	15.3
0.76804	20379.5	418.8	-32.7	51.0	0.0	0.0	0.0	11.1
0.89605	20302.8	488.8	-17.7	26.0	0.0	0.0	0.0	7.6
1.0241	20316.4	544.1	-3.3	3.3	0.0	0.0	0.0	4.7
1.1521	20350.2	593.3	10.9	-18.5	0.0	0.0	0.0	1.9
1.2801	20382.7	633.7	25.1	-38.4	0.0	0.0	0.0	-1.3
1.4081	20439.9	672.9	39.4	-58.2	0.0	0.0	0.0	-4.2
1.5361	20666.1	697.2	53.2	-76.0	0.0	0.0	0.0	-6.3
1.6641	20924.2	712.8	66.3	-92.7	0.0	0.0	0.0	-8.4
1.7921	21197.8	724.5	79.3	-109.2	0.0	0.0	0.0	-10.6
1.9201	21498.8	733.6	91.8	-125.1	0.0	0.0	0.0	-12.8
2.0481	21707.4	738.2	100.9	-138.9	0.0	0.0	0.0	-14.7
2.1761	21922.6	741.7	110.6	-153.1	0.0	0.0	0.0	-16.7
2.3041	22112.4	743.5	119.5	-166.9	0.0	0.0	0.0	-18.8
2.4321	22284.0	744.5	127.9	-180.1	0.0	0.0	0.0	-20.8
2.5601	22453.0	744.3	136.1	-193.1	0.0	0.0	0.0	-22.9

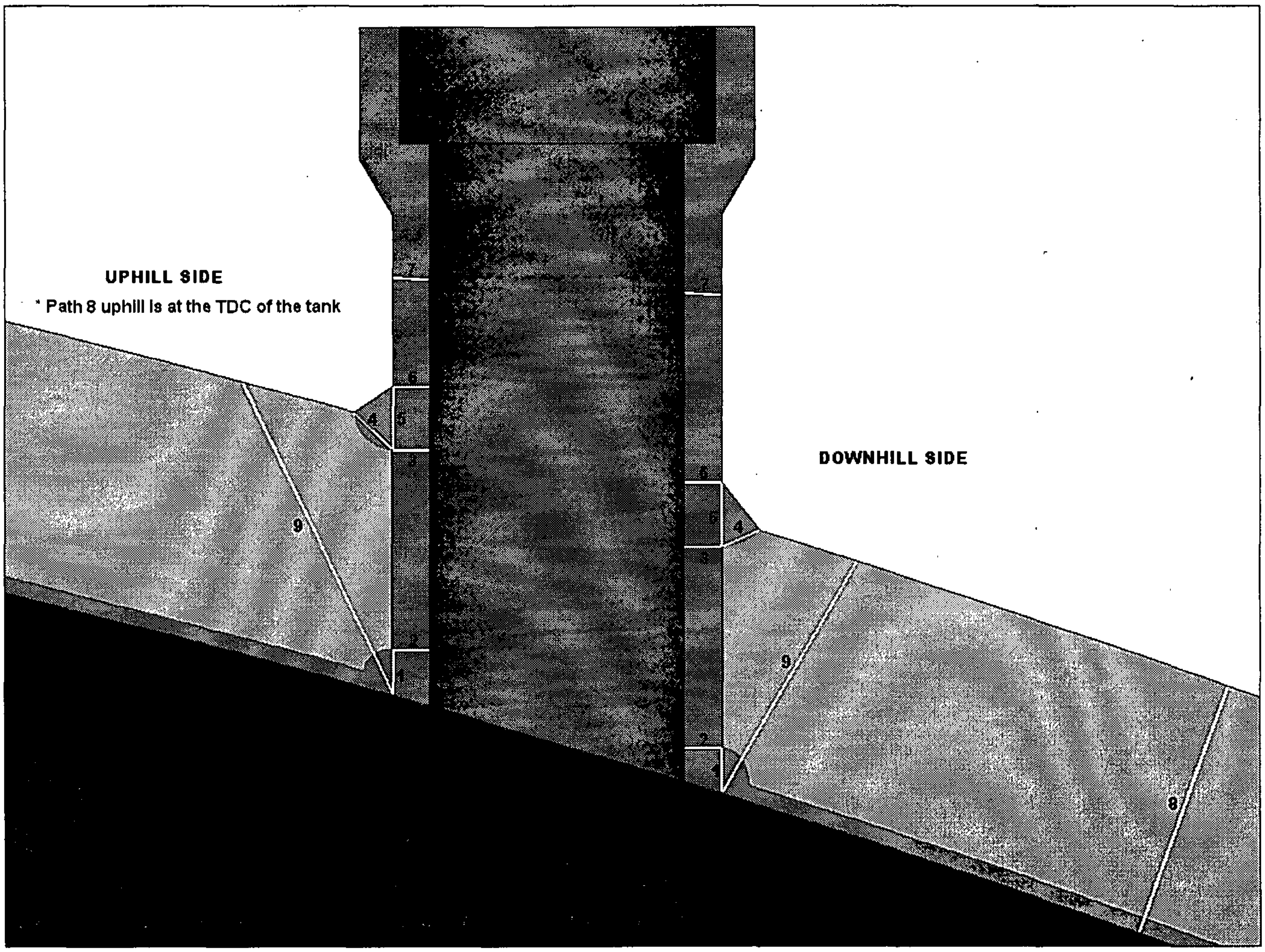

Figure 1: SIT Vent Relief Nozzle Penetration Through-Wall Stress Paths
Note: Paths 1 through 8 are used for the Section III design analysis only.

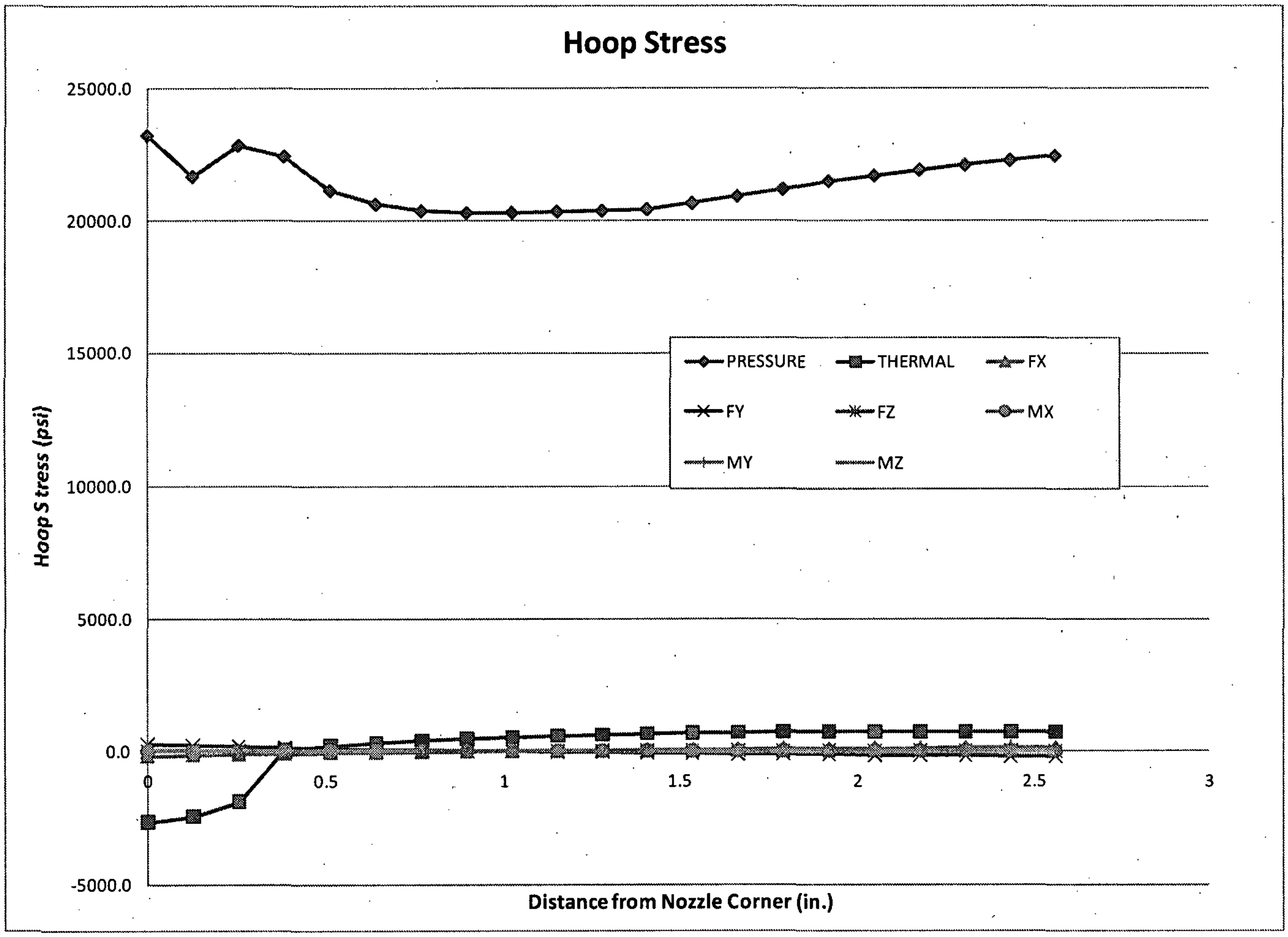

Figure 2: Maximum Hoop Stress Distribution from SIT Nozzle Corner

4.0 ASSUMPTIONS

1. It is assumed that a nozzle corner flaw exists in the original J-Groove weld that attaches the vent relief nozzle to the SIT shell at its inside surface. Therefore, analyses performed herein assume an assumed initial flaw size equal to the size of the existing J-Groove weld.

2. The postulated nozzle corner crack is assumed to grow congruently in the SIT shell, keeping its same shape and a constant aspect ratio.

3. The total number of specified full pressure cycles transients which correspond to a 40-year plant life (20-year remaining life plus 20-year life extension) will be used in this evaluation for crack growth purposes.

5.0 STRESS INTENSITY FACTORS

The base material of the SIT shell has been UT inspected and found to be free of defects [5]. Thus, for the fracture mechanics evaluation, it is assumed that the remnant J-Groove weld at the inside surface of the SIT is completely flawed. Consequently, an initial nozzle corner flaw encompassing the full cross-section of the J-groove weld is postulated. The flaw is axially oriented with respect the SIT vent relief nozzle. The appropriate crack model used for this evaluation is a corner crack model, *Simulated 3-D Nozzle Crack,* from the **pc-CRACK**™ [6] library which is illustrated in Figure 3.

The stress intensity factors for the postulated nozzle corner crack are computed with **pc-CRACK**™ for starting for various flaw sizes. The calculated stress intensity factor distributions are listed in Table 2 and plotted in Figure 4.

The **pc-CRACK**™ output file is listed in Appendix B.

Table 2: Stress Intensity Factors (psi-√in)

Crack Depth (in.)	Pressure	Thermal	Nozzle Loads	Total
0.040	5807.4	-681.2	38.6	5164.8
0.120	9965.0	-1066.2	63.2	8962.0
0.200	12751.7	-1239.5	77.0	11589.3
0.280	14963.2	-1315.7	86.0	13733.4
0.360	16835.2	-1333.1	91.9	15594.0
0.400	17680.3	-1326.1	94.0	16448.1
0.480	19232.6	-1289.4	96.9	18040.1
0.520	19951.7	-1262.1	97.8	18787.4
0.600	21298.0	-1705.8	98.7	19691.0
0.640	21931.9	-1155.1	98.8	20875.7
0.720	23134.4	-1069.6	98.4	22163.2
0.800	24263.5	-977.7	97.3	23383.0
0.840	24804.6	-930.4	96.5	23970.7
0.920	25846.8	-834.4	94.5	25106.9
1.000	26842.9	-738.5	92.1	26196.5
1.040	27326.0	-691.1	90.8	26725.7
1.120	28266.2	-598.2	87.9	27755.8
1.200	29176.3	-509.0	84.7	28752.0
1.280	30060.9	-424.1	81.4	29718.2
1.320	30494.8	-383.5	79.6	30190.9
1.400	31347.9	-306.2	76.0	31117.7
1.440	31767.9	-269.5	74.1	31572.5
1.480	32183.9	-234.2	72.2	32021.9
1.520	32596.3	-200.3	70.3	32466.3
1.560	33005.3	-167.7	68.4	32906.0
1.600	33411.2	-136.5	66.4	33341.2
1.640	33814.2	-106.5	64.4	33772.1
1.680	34214.6	-77.8	62.4	34199.2
1.720	34612.5	-50.4	60.4	34622.5
1.760	35008.1	-24.1	58.4	35042.4
1.800	35401.5	1.2	56.3	35459.0
1.840	35793.0	25.4	54.3	35872.6
1.880	36182.7	48.6	52.2	36283.5
1.920	36570.7	71.0	50.1	36691.8
1.960	36957.0	92.7	47.9	37097.6
2.000	37341.9	113.7	45.8	37501.4

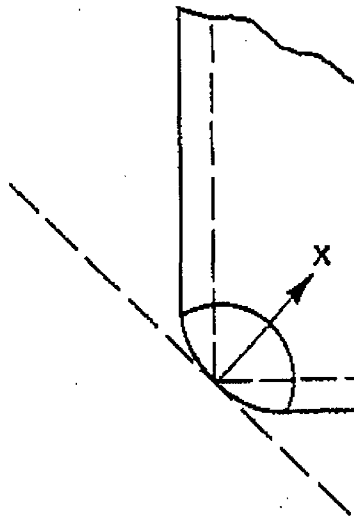

Figure 3: Simulated 3-D Nozzle Corner Crack Model

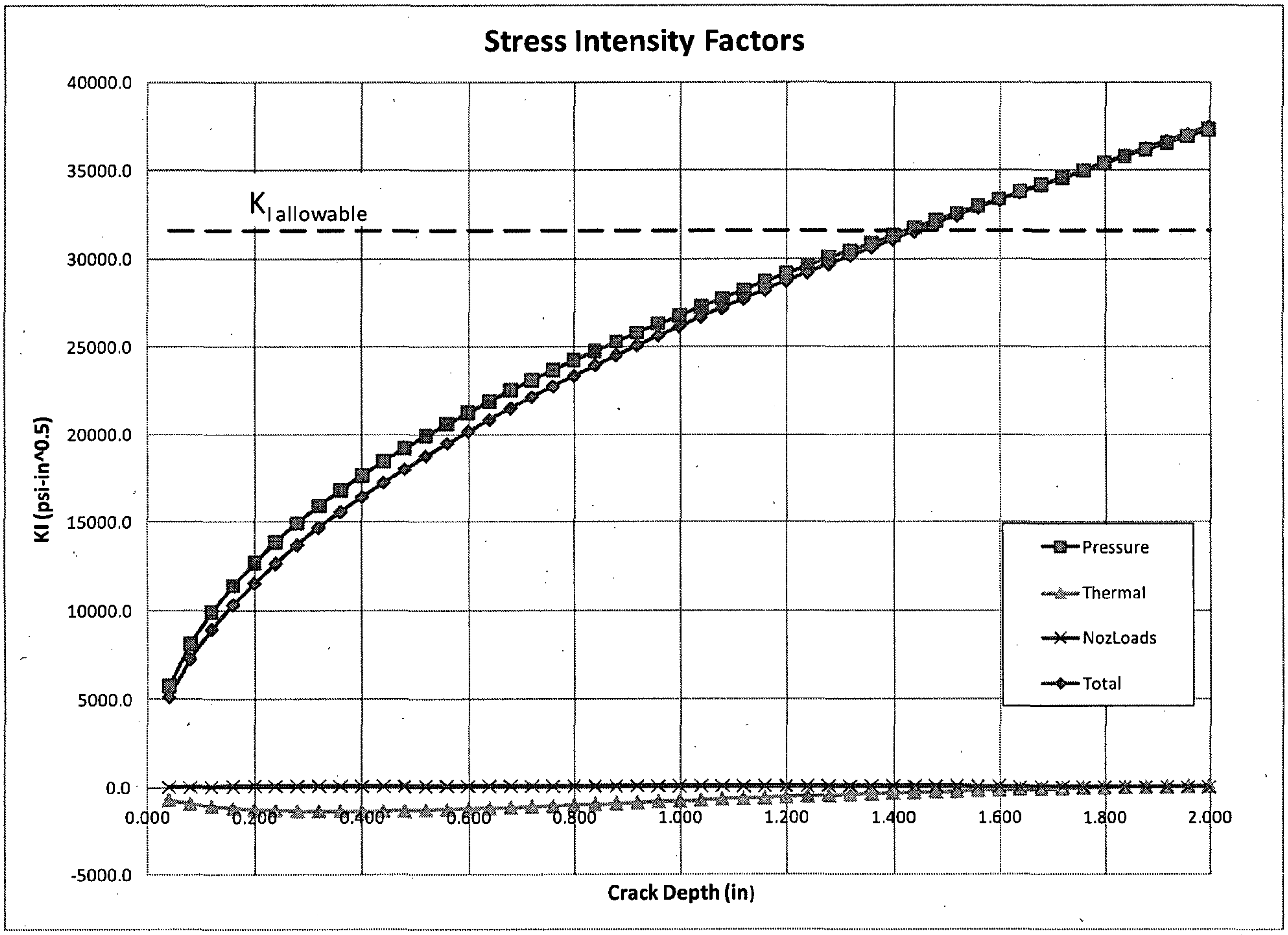

Figure 4: Safety Injection Tank Nozzle Penetration Stress Intensity Factors

6.0 ALLOWABLE FLAW SIZE

6.1 Fracture Toughness

Material test data for the SA-516 Grade 70 material of the SIT shell are provided in Reference 7. The CMTR show that the SIT material exhibits a minimum Charpy V-Notch (CVN) impact energy of 86 ft-lb at 60°F. The maximum reported CVN value was 118 ft-lb.

The CVN value of the material can be used to estimate K_{Ic}. Rolfe and Barsom [8] include several relationships between K_{Ic} and CVN for materials in the toughness transition temperature region. One of the relationship is:

$$K_{Ic}^2/E = A(CVN)$$

where, E is the elastic modulus and A is a constant ranging from about 4 to 5.

Using the expression above with $E = 29.1 \times 10^6$ psi at 150°F [9], A = 4 to 5 and CVN = 86 ft-lb, the fracture toughness, K_{Ic}, for the SIT shell material is calculated to vary from a minimum value of 100.0 to 118.8 ksi$\sqrt{in}$ at the 60°F test temperature. The actual fracture toughness of the SIT at its normal operating temperature of 140°F will be much higher. Thus, the use of the modulus of elasticity at the operating temperature rather than at the design temperature is justified.

6.2 Critical and Allowable Flaw Sizes

The stress intensity factors calculated in Section 5 are used to determine the critical flaw size for the SIT shell at the vent relief nozzle penetration. The critical flaw size is determined by comparing the calculated stress intensity factors to the SIT lower bound material toughness. As shown in Figure 4, the calculated total stress intensity factor is less than the fracture toughness for flaw sizes up to the full thickness of the SIT shell.

The flaw acceptance criteria of IWC-3610 of Section XI of the ASME Code [1] are applicable for this evaluation. IWC-3610 stipulates that the criteria of IWB-3610 may be applied. Hence, the flaw acceptance criteria based on applied stress intensity factor of IWB-3612 are used to calculate the allowable flaw size. For normal and upset conditions, IWB-3612 requires a safety factor of $\sqrt{10}$ on the material toughness to obtain the allowable fracture toughness, such that:

$$K_I \leq K_{Ia}/\sqrt{10}$$

where,

K_I = maximum applied stress intensity factor
K_{Ia} = available fracture toughness based on crack arrest for the corresponding crack tip temperature

Reference 10 documents the technical basis for the use of the available fracture toughness based on fracture initiation, K_{Ic}, instead of K_{Ia} in the evaluation of flaws in vessels. In fact, the 2007 edition of Section XI of the ASME Code has incorporated that change in the flaw acceptance criteria.

Using the lower bound SIT shell material toughness calculated above (K_{Ic} = 100 ksi$\sqrt{in}$), the allowable flaw size is determined as the flaw size which corresponds to a stress intensity factor equal to K_{Ic} = $100/\sqrt{10}$ = 31.6 ksi$\sqrt{in}$. As shown in Table 2 and Figure 4, the allowable flaw size is equal to 1.44 inches.

7.0 FATIGUE CRACK GROWTH ANALYSIS

7.1 Fatigue Crack Growth Cycles

The applicable cyclic loadings specified in the design specification of the safety injection tank [11] are the full pressure cycles, hydrostatic tests and blowdown tests. The number of design cycles over a 40-year period (20-year remaining life plus 20-year life extension) is listed in Table 3 along with the corresponding internal pressure level for each event.

Table 3: Event Cycles

Event	Cycles	Pressure (psi)
Pressure Transients	500	650
Hydrostatic Test	20	883 max.
Blowdown Test	10	650

7.2 Fatigue Crack Growth Rate

The postulated flaw in the original attachment weld can potentially grow due to cyclic fatigue loading in the SIT shell. The methodology of Section XI, Appendix A of the ASME Code [1] was used to perform the fatigue crack growth analysis. The fatigue crack growth rate (da/dN) for the ferritic steel SIT material is a function of the range of applied stress intensity factor (ΔK_I) that can be expressed in the form of a Paris law. The ASME Code, Section XI reference fatigue crack growth curves for low alloy steels in air environments are used for the evaluation of the SIT shell. The curves are given as:

$$\frac{da}{dN} = C_O(\Delta K_I)^n$$

where,

a	=	flaw depth (in.)
N	=	number of stress cycles
ΔK_I	=	stress intensity factor range (ksi$\sqrt{\text{in}}$)
R	=	K_{min}/K_{max}
n	=	3.07
C_O	=	1.99×10^{-10} S

with,

For $0 \leq R \leq 1.0$ $\quad S = 25.72(2.88-R)^{-3.07}$ and $\Delta K_I = K_{min} - K_{max}$

For $R < 0$ and $K_{max} - K_{min} > 1.12\sigma_f\sqrt{\pi a}$ $S = 1$ and $\Delta K_I = K_{min} - K_{max}$

For $-2 \le R \le 0$ and $K_{max} - K_{min} < 1.12\sigma_f\sqrt{\pi a}$ $S = 1$ and $\Delta K_I = K_{max}$

For $R < -2$ and $K_{max} - K_{min} \le 1.12\sigma_f\sqrt{\pi a}$ $S = 1$ and $\Delta K_I = (1-R)K_{max}/3$

where,

σ_f = material flow stress = ½(σ_{ys} + σ_{ult})
σ_{ys} = material yield strength
σ_{ult} = material ultimate tensile strength

7.3 End of Plant Life Fatigue Crack Growth Analysis

The fatigue crack growth analyses are performed with the fracture mechanics software program **pc-CRACK™** [6] using the stress intensity factors calculated in Section 5 for a postulated corner crack and the 40-year (20-year remaining life plus 20-year life extension) design life cycles in Table 3. The use of **pc-CRACK™** is appropriate since the R ratio is zero in this evaluation. Based on the assumption of a nozzle corner flaw encompassing the entire cross-section of the existing weld, the initial flaw depth is taken as the depth of the remnant J-Groove weld at the SIT inside surface, i.e., a_i = 0.351" [3].

In the fatigue crack growth analysis, appropriate scale factors based on the internal pressure levels in Table 3 are used to determine the stress intensity factors due to the full pressure cycles as well as the hydrostatic and blowdown tests. For output purposes, the cycles are grouped in 40 sub-blocks, each sub-block representing a year of plant operation. Since there is less than 1 occurrence per year for the tests, the analysis is performed conservatively using 1 occurrence per year for both of the hydrostatic and blowdown test.

The results of the fatigue crack growth evaluation are presented in Table 4 and illustrated in Figure 5. It is shown that the postulated flaw grows by only 1 mil to a final depth of 0.352 inches after 40 years of plant operation (20-year remaining life plus 20-year life extension).

The **pc-CRACK™** output files for the crack growth analyses are presented in Appendix B.

Table 4: Crack Growth Results

Total Cycles	Kmax (ksi-in$^{1/2}$)	Kmin (ksi-in$^{1/2}$)	DeltaK (ksi-in$^{1/2}$)	R	Da/Dn	Da (in)	a (in)
13	1.54E+04	0.00E+00	1.54E+04	0	8.78E-07	8.78E-07	0.351
30	1.66E+04	0.00E+00	1.66E+04	0	1.11E-06	1.11E-06	0.351
60	1.66E+04	0.00E+00	1.66E+04	0	1.11E-06	1.11E-06	0.3511
90	1.66E+04	0.00E+00	1.66E+04	0	1.11E-06	1.11E-06	0.3511
120	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3511
150	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3512
180	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3512
210	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3512
240	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3512
270	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3513
300	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3513
330	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3513
360	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3514
390	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3514
420	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3514
450	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3515
480	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3515
510	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3515
540	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3516
570	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3516
600	1.66E+04	0.00E+00	1.66E+04	0	1.12E-06	1.12E-06	0.3516

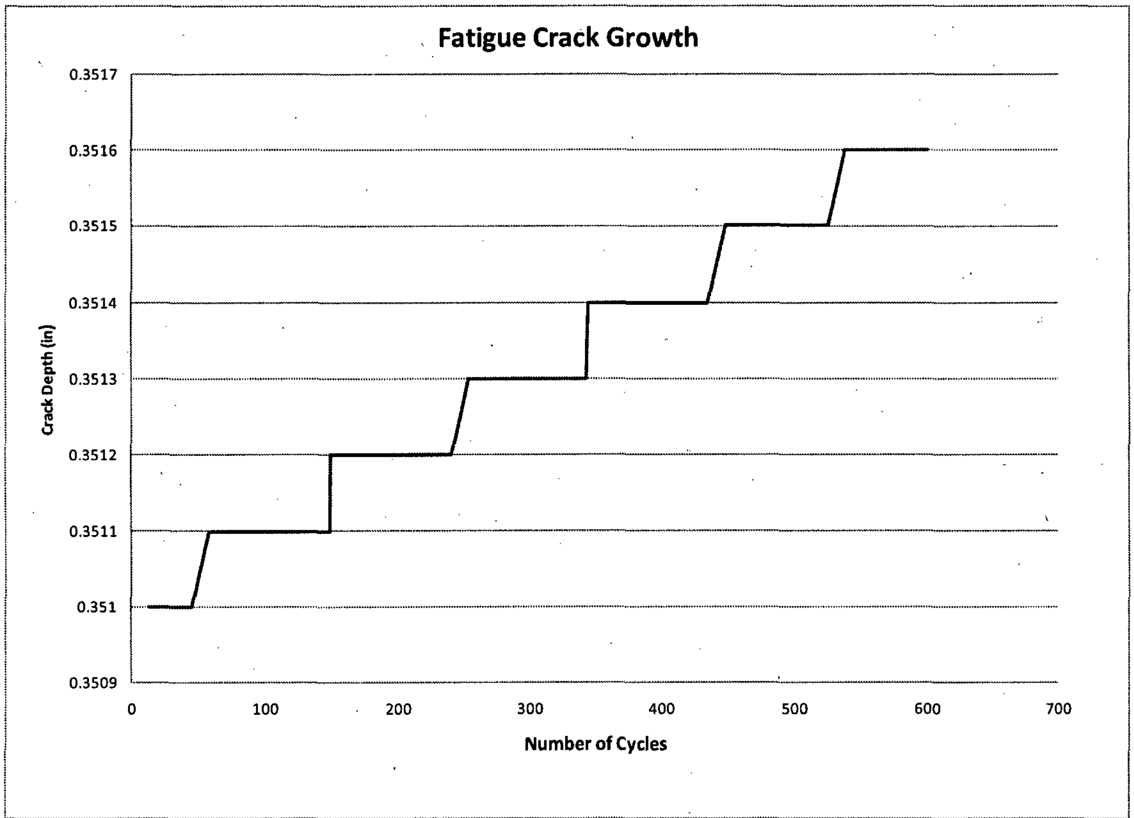

Figure 5: Crack Growth of Postulated Flaws in SIT Shell

8.0 CONCLUSIONS

Fracture mechanics analyses have been performed to assess the impact of leaving a flaw in the original J-Groove weld after repair of the vent relief nozzle of Palo Verde, Unit 1, Safety Injection Tank 1A. Based on the results of the evaluation presented herein, the postulated nozzle corner flaw is acceptable and meets the requirements of ASME Code, Section XI, IWC-3610 [1]. The allowable flaw size for the SIT shell at the vent relief penetration is 1.44 inches and the critical flaw size is larger than the thickness of the SIT.

A fatigue crack growth analysis was performed to determine the potential for crack propagation into the SIT shell. The postulated initial flaw of 0.351" depth grows only by 1 mil for the 40-year design plant life (20-year remaining life plus 20-year life extension). The final crack size at the end of SIT service life is 0.352 inches, which is much less than the calculated allowable flaw size of 1.44 inches. The applied stress intensity factor at the end of service life is also less than the allowable fracture toughness.

The results of the fracture mechanics evaluation presented herein, which are based on more detailed analyses, supersede those documented in Reference 13.

9.0 REFERENCES

1. ASME Boiler and Pressure Vessel Code, Section XI, 2001 Edition with Addenda through 2003.
2. Structural Integrity Calculation 0800802.303, Rev. 0, "Thermal and Mechanical Stress Analyses of Safety Injection Tank Vent Nozzle Relief."
3. Bechtel Corporation Report TR-76-61," Analysis of a System 80 Safety Injection Tank, Main Report," Revision 08, Prepared by NUS Corporation, April 1981, APS Sdoc #N001-11.02-41-1, SI File No. 0800802.201.
4. ANSYS/Mechanical, Release 8.1 (w/ Service Pack 1), ANSYS, Inc., June 2004.
5. Palo Verde Nuclear Generating Station, Ultrasonic Examination Report, Report No. 08-513, June 7, 2008, SI File No. 0800802.205.
6. **pc-CRACK™** for Windows, Version 3.1-98348, Structural Integrity Associates, 1998.
7. Lukens Steel Company Test Certificate for SA 516 Gr. 70, Dated 4/19/77, SI File No. 0800802.205.
8. S. T. Rolfe and J. M. Barsom, Fracture and Fatigue Control in Structures, 2nd Edition, Prentice-Hall, NJ, 1987.
9. ASME Boiler and Pressure Vessel Code, Section II, Part D, 2001 Edition with Addenda through 2003.
10. R. Cipolla and K. Wichman, "Technical Basis for Revised Flaw Acceptance Criteria Under IWB-3610 of ASME Code Section XI," PVP2005-71718, July 2005.
11. APS Supplier Number Sdoc N001-11.02-5-6, Combustion Engineering, Inc., "Standard Specification for Safety Injection Tanks for System 80 Standard Design," Specification No. SYS80-PE-601, Rev. 3, January 1978. File No. 0800802.204.
12. Structural Integrity Calculation 0800802.305, Rev. 0, "ASME Code Evaluation of Safety Injection Tank Vent Relief Nozzle Repair."
13. Structural Integrity Calculation 0800802.301, Rev. 0, "Safety Injection Tank Nozzle Repair Design Analysis."

APPENDIX A

ANSYS Post-Processing Output Files List

Filename	Description
PRESSURE_MAP.OUT	Through-Wall Stress Distribution due to Pressure
THERMAL_MAP.OUT	Through-Wall Stress Distribution due to Thermal Load
FX_MAP.OUT	Through-Wall Stress Distribution due to X-Direction Force
FY_MAP.OUT	Through-Wall Stress Distribution due to Y-Direction Force
FZ_MAP.OUT	Through-Wall Stress Distribution due to Z-Direction Force
MX_MAP.OUT	Through-Wall Stress Distribution due to X-Direction Moment
MY_MAP.OUT	Through-Wall Stress Distribution due to Y-Direction Moment
MZ_MAP.OUT	Through-Wall Stress Distribution due to Z-Direction Moment

APPENDIX B

pc-CRACK™ Output files

Filename	Description	Pages
SIT_NOZL.OUT	Fatigue Crack Growth Analysis	B2 – B10

Linear Elastic Fracture Mechanics

Date: Fri Jul 04 11:30:38 2008
Input Data and Results File: SIT_NOZL.LFM

Title: PV Safety Injection Tank Vent Relief Nozzle Repair

Load Cases:

Case ID: Pressure --- Stress Distribution

Depth	Stress
0.0000	23238.1992
0.1280	21670.4004
0.2560	22855.3008
0.3840	22437.4004
0.5120	21146.5000
0.6400	20625.1992
0.7680	20379.5000
0.8960	20302.8008
1.0240	20316.4004
1.1520	20350.1992
1.2800	20382.6992
1.4080	20439.9004
1.5360	20666.0996
1.6640	20924.1992
1.7920	21197.8008
1.9200	21498.8008
2.0480	21707.4004
2.1760	21922.5996
2.3040	22112.4004
2.4320	22284.0000
2.5600	22453.0000

Case ID: NozLoads --- Stress Distribution

Depth	Stress

0.0000	158.8000
0.1280	126.5000
0.2560	107.8000
0.3840	88.4000
0.5120	64.7000
0.6400	45.5000
0.7680	29.3000
0.8960	15.9000
1.0240	4.6000
1.1520	-5.7000
1.2800	-14.6000
1.4080	-23.0000
1.5360	-29.1000
1.6640	-34.8000
1.7920	-40.4000
1.9200	-46.0000
2.0480	-52.6000
2.1760	-59.2000
2.3040	-66.2000
2.4320	-73.1000
2.5600	-79.8000

Case ID: Thermal --- Stress Distribution

Depth	Stress
0.0000	-2673.1599
0.1280	-2448.8101
0.2560	-1904.4200
0.3840	67.8538
0.5120	216.0760
0.6400	328.9650
0.7680	418.8240
0.8960	488.8170
1.0241	544.1030
1.1521	593.2710
1.2801	633.7030
1.4081	672.9380
1.5361	697.2210
1.6641	712.8100
1.7921	724.5000
1.9201	733.6000
2.0481	738.2200
2.1761	741.6500
2.3041	743.5400
2.4321	744.4500
2.5601	744.3100

Stress Coefficients

Case ID	C0	C1	C2	C3	Type
Pressure	23317.9	-5951.27	3603.48	-543.2	StressDist
NozLoads	158.829	-230.887	96.0423	-16.5247	StressDist
Thermal	-2860	7243.89	-4579.15	910.24	StressDist

Crack Model: Simulated 3-D Nozzle Corner Crack

WARNING: The stress intensity factor (K) is calculated at the deepest point only. May be non-conservative in some cases.

Crack Parameters:
Max. crack size: 2.0000

Crack Size	Stress Intensity Factor: Case Pressure	Case NozLoads	Case Thermal
0.0400	5807.38	38.643	-681.237
0.0800	8174	53.1178	-916.188
0.1200	9965	63.2208	-1066.2
0.1600	11455.1	70.9288	-1168.8
0.2000	12751.7	77.0352	-1239.48
0.2400	13910	81.9612	-1286.68
0.2800	14963.2	85.9657	-1315.72
0.3200	15933.2	89.2233	-1330.28
0.3600	16835.2	91.8595	-1333.06
0.4000	17680.3	93.9687	-1326.13
0.4400	18477.2	95.6244	-1311.13
0.4800	19232.6	96.8855	-1289.4
0.5200	19951.7	97.8003	-1262.06
0.5600	20638.9	98.4092	-1230.04
0.6000	21298	98.7461	-1194.14
0.6400	21931.9	98.8404	-1155.05
0.6800	22543.3	98.7172	-1113.37
0.7200	23134.4	98.3988	-1069.63
0.7600	23707.3	97.9046	-1024.28
0.8000	24263.5	97.2518	-977.748
0.8400	24804.6	96.4558	-930.381
0.8800	25332	95.5302	-882.501
0.9200	25846.8	94.4874	-834.392
0.9600	26350.1	93.3385	-786.306
1.0000	26842.9	92.0935	-738.464
1.0400	27326	90.7615	-691.063
1.0800	27800.2	89.3505	-644.273
1.1200	28266.2	87.8682	-598.246
1.1600	28724.8	86.3211	-553.111
1.2000	29176.3	84.7155	-508.981
1.2400	29621.6	83.0568	-465.948
1.2800	30060.9	81.35	-424.093
1.3200	30494.8	79.5997	-383.478
1.3600	30923.7	77.81	-344.153
1.4000	31347.9	75.9845	-306.154
1.4400	31767.9	74.1265	-269.504
1.4800	32183.9	72.239	-234.215

1.5200	32596.3	70.3244	-200.288
1.5600	33005.3	68.3851	-167.713
1.6000	33411.2	66.4231	-136.469
1.6400	33814.2	64.44	-106.526
1.6800	34214.6	62.4373	-77.8455
1.7200	34612.5	60.4162	-50.3779
1.7600	35008.1	58.3776	-24.0666
1.8000	35401.5	56.3222	1.15363
1.8400	35793	54.2505	25.3563
1.8800	36182.7	52.1628	48.6224
1.9200	36570.7	50.0592	71.0405
1.9600	36957	47.9396	92.7064
2.0000	37341.9	45.8037	113.723

Crack Growth Laws:

Law ID: Carbon Steel in Air
Model: ASME Section XI - ferritic steel in air environment

```
      da/dN = C * S * dK^3.07
where
         S = 25.72 * (2.88 - R')^(-3.07)
         R = 0      for  R < 0
         R'= R      for  R >= 0
        dK = Kmax - Kmin
         R = Kmin / Kmax
```

where:
C = 1.2270e-019
is for the currently selected units of:
force: lb
length: inch

Material Fracture Toughness KIc:

Material ID: SA-516 Gr 70

Depth	KIc
0.0000	100000.0000
2.6000	100000.0000

Initial crack size= 0.3510
Max. crack size= 2.0000

Number of blocks= 40
Print increment of block= 1

Subblock	Cycles /Time	Calc. incre.	Print incre.	Crk. Grw. Law	Mat. K1c

Full Pressure	13	1	13	Carbon Steel in SA-516 Gr 70
Hydrostatic	1	1	1	Carbon Steel in SA-516 Gr 70
Blowdown	1	1	1	Carbon Steel in SA-516 Gr 70

Subblock	Kmax Case ID	Kmax Scale Factor	Kmin Case ID	Kmin Scale Factor
Full Pressure	Pressure	1.0000		
	Thermal	1.0000		
	NozLoads	1.0000		
Hydrostatic	Pressure	1.3600		
Blowdown	Pressure	1.0000		

Crack growth results:

Total Cycles /Time	Subblock Cycles /Time	Kmax	Kmin	DeltaK	R	DaDn /DaDt	Da	a	a/thk
Block:	1								
13	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.78e-007	8.78e-007	0.351	0.00
14	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.86e-006	2.86e-006	0.351	0.00
15	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.11e-006	1.11e-006	0.351	0.00
Block:	2								
28	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.351	0.00
29	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.86e-006	2.86e-006	0.351	0.00
30	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.11e-006	1.11e-006	0.351	0.00
Block:	3								
43	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.351	0.00
44	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.351	0.00
45	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.11e-006	1.11e-006	0.351	0.00
Block:	4								
58	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3511	0.00
59	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3511	0.00
60	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.11e-006	1.11e-006	0.3511	0.00
Block:	5								
73	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3511	0.00
74	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3511	0.00
75	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.11e-006	1.11e-006	0.3511	0.00
Block:	6								
88	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3511	0.00
89	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3511	0.00
90	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.11e-006	1.11e-006	0.3511	0.00
Block:	7								

103	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3511	0.00
104	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3511	0.00
105	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3511	0.00
Block: 8									
118	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3511	0.00
119	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3511	0.00
120	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3511	0.00
Block: 9									
133	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3511	0.00
134	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3511	0.00
135	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3511	0.00
Block: 10									
148	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3511	0.00
149	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3512	0.00
150	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3512	0.00
Block: 11									
163	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3512	0.00
164	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3512	0.00
165	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3512	0.00
Block: 12									
178	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3512	0.00
179	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3512	0.00
180	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3512	0.00
Block: 13									
193	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3512	0.00
194	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3512	0.00
195	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3512	0.00
Block: 14									
208	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3512	0.00
209	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3512	0.00
210	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3512	0.00
Block: 15									
223	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3512	0.00
224	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3512	0.00
225	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3512	0.00
Block: 16									
238	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3512	0.00
239	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3512	0.00
240	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3512	0.00
Block: 17									
253	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3513	0.00
254	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3513	0.00
255	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3513	0.00

Block: 18									
268	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.79e-007	8.79e-007	0.3513	0.00
269	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3513	0.00
270	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3513	0.00
Block: 19									
283	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3513	0.00
284	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3513	0.00
285	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3513	0.00
Block: 20									
298	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3513	0.00
299	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3513	0.00
300	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3513	0.00
Block: 21									
313	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3513	0.00
314	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3513	0.00
315	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3513	0.00
Block: 22									
328	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3513	0.00
329	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3513	0.00
330	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3513	0.00
Block: 23									
343	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3513	0.00
344	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3514	0.00
345	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3514	0.00
Block: 24									
358	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3514	0.00
359	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3514	0.00
360	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3514	0.00
Block: 25									
373	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3514	0.00
374	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3514	0.00
375	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3514	0.00
Block: 26									
388	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3514	0.00
389	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3514	0.00
390	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3514	0.00
Block: 27									
403	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3514	0.00
404	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3514	0.00
405	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3514	0.00
Block: 28									
418	13	1.54e+004	0.00e+000	1.54e+004	0.00	8.80e-007	8.80e-007	0.3514	0.00
419	1	2.26e+004	0.00e+000	2.26e+004	0.00	2.87e-006	2.87e-006	0.3514	0.00
420	1	1.66e+004	0.00e+000	1.66e+004	0.00	1.12e-006	1.12e-006	0.3514	0.00

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Block:    29
     433        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.80e-007 8.80e-007 0.3514 0.00
     434         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3514 0.00
     435         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3514 0.00

Block:    30
     448        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.80e-007 8.80e-007 0.3515 0.00
     449         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3515 0.00
     450         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3515 0.00

Block:    31
     463        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.80e-007 8.80e-007 0.3515 0.00
     464         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3515 0.00
     465         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3515 0.00

Block:    32
     478        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.80e-007 8.80e-007 0.3515 0.00
     479         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3515 0.00
     480         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3515 0.00

Block:    33
     493        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.80e-007 8.80e-007 0.3515 0.00
     494         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3515 0.00
     495         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3515 0.00

Block:    34
     508        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.80e-007 8.80e-007 0.3515 0.00
     509         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3515 0.00
     510         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3515 0.00

Block:    35
     523        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.81e-007 8.81e-007 0.3515 0.00
     524         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3515 0.00
     525         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3515 0.00

Block:    36
     538        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.81e-007 8.81e-007 0.3516 0.00
     539         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3516 0.00
     540         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3516 0.00

Block:    37
     553        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.81e-007 8.81e-007 0.3516 0.00
     554         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3516 0.00
     555         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3516 0.00

Block:    38
     568        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.81e-007 8.81e-007 0.3516 0.00
     569         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3516 0.00
     570         1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3516 0.00

Block:    39
     583        13 1.54e+004 0.00e+000 1.54e+004 0.00 8.81e-007 8.81e-007 0.3516 0.00
     584         1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3516 0.00
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     585          1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3516 0.00

Block:    40
     598         13 1.54e+004 0.00e+000 1.54e+004 0.00 8.81e-007 8.81e-007 0.3516 0.00
     599          1 2.26e+004 0.00e+000 2.26e+004 0.00 2.87e-006 2.87e-006 0.3516 0.00
     600          1 1.66e+004 0.00e+000 1.66e+004 0.00 1.12e-006 1.12e-006 0.3516 0.00
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End of pc-CRACK Output